Australian Government
Productivity Commission

Carbon Emission Policies in Key Economies

Productivity Commission
Research Report

May 2011

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ISBN 978-1-74037-353-1

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An appropriate citation for this paper is:

Productivity Commission 2011, *Carbon Emission Policies in Key Economies*, Research Report, Canberra.

JEL code: Q5, Q54

The Productivity Commission

The Productivity Commission is the Australian Government's independent research and advisory body on a range of economic, social and environmental issues affecting the welfare of Australians. Its role, expressed most simply, is to help governments make better policies, in the long term interest of the Australian community.

The Commission's independence is underpinned by an Act of Parliament. Its processes and outputs are open to public scrutiny and are driven by concern for the wellbeing of the community as a whole.

Further information on the Productivity Commission can be obtained from the Commission's website (www.pc.gov.au) or by contacting Media and Publications on (03) 9653 2244 or email: maps@pc.gov.au

Foreword

The Australian Government commissioned this report to help it, and the Multi-Party Climate Change Committee, assess the extent to which key economies are taking action to address climate change. It provides a stocktake of the large number of policy measures in the electricity generation and road transport sectors of the countries studied. And it provides estimates of the burdens associated with these policies in each country and the abatement achieved. While the results are based on a robust methodology, data limitations have meant that some estimates could only be indicative.

In conducting the study, the Commission consulted with government agencies responsible for emissions-reduction policies in China, Germany, India, Japan, New Zealand, South Korea, the United Kingdom and the United States, as well as Australia. The Commission received information and data from a number of expert bodies internationally, including the Institute of Energy Economics in Japan. The Department of Foreign Affairs and Trade and its overseas embassies provided invaluable assistance in facilitating contact with governments and organisations in the study countries. The Commission also hired a number of firms in Australia and internationally to assist with the acquisition of information on emissions-reduction policies.

The timeframes and the nature of the exercise precluded the wide community involvement typical of the Commission's public inquiries. That said, the Commission was able to obtain a range of input and feedback on both the methodology and data through a workshop, exposure drafts sent to experts and study countries, and various meetings with stakeholders during the course of the study. The Commission is very grateful to all those who provided information and analytical input.

The study was prepared by a research team from the Commission's Melbourne office, headed by Paul Belin. In overseeing the project, I was assisted by Commissioner Warren Mundy.

Gary Banks AO
Chairman
May 2011

Terms of reference

Study into Emissions Reduction Policies in Key Economies

Productivity Commission Act 1998

I, Bill Shorten, pursuant to Parts 2 and 4 of the Productivity Commission Act 1998 hereby request the Productivity Commission to undertake a research study on effective carbon prices that result from emissions and energy reduction policies in place or committed in Australia and other key economies.

This work is intended to provide accurate and timely information on the extent of climate action in key economies and sectors.

Context

Reducing greenhouse gas emissions to mitigate the worst effects of climate change is a global challenge. Various mitigation policies are available, though not all impose explicit carbon prices on businesses and households. While some policies such as carbon taxes or emissions trading schemes will involve explicit carbon prices others, such as direct regulation of technologies, renewable energy targets, or subsidies for low emissions technology, impose less transparent carbon prices.

Given this, comparing the impact of different policies on a given sector across economies can be difficult as their scope can vary considerably and their impacts are not always clear. In this context it is important to develop a methodology for aggregating sectoral impacts across policies, and for making comparisons across key economies.

Against this background, the Commission is requested to provide advice on the effective carbon prices that result from emissions reduction and other relevant policies in key economies, where effective carbon prices include both explicit carbon prices, such as taxes or emissions trading schemes, and implicit carbon prices.

Scope of the Study

The Commission is requested to:

- examine and detail emissions reduction policies, either in place or committed in Australia and in other key economies such as the UK, the USA, Germany, New Zealand, China, India, Japan and South Korea

- estimate the effective carbon price per tonne of CO2-e faced by the electricity generation sectors in these economies, and selected industries drawn from manufacturing and transport sectors in these and other countries where relevant and data permitting

- report on the methodology, assumptions and data sources used, so as to inform further analysis in this area.

Key Considerations

In conducting the study and making recommendations the Commission would:

- consult with the business sector, government agencies and other interested parties as appropriate in Australia and internationally

- draw on credible evidence both nationally and internationally, including by utilising local research expertise in economies being examined.

The Commission is to report to the Government by the end of May 2011. The report will be published.

Bill Shorten

Assistant Treasurer

[Received 15 November 2010]

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O Demand-side analysis for road transport
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Abbreviations

ACT	Australian Capital Territory
AEMO	Australian Electricity Market Operator
CAFE	Corporate Average Fuel Economy
CARB	California Air Resources Board
CARD	Center for Agricultural and Rural Development
CCL	Climate Change Levy
CCS	Carbon capture and storage
CER	Certified Emissions Reductions
CFGS	Cleaner Fuels Grants Scheme
CHP	Combined heat and power
CHP Act	Combined Heat and Power Act
CNY	Chinese Yuan
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
CSI	California Solar Initiative
DCCEE	Department of Climate Change and Energy Efficiency
DECC	Department of Energy and Climate Change (UK)
E10	Mixture of 10 per cent ethanol and 90 per cent petrol
E85	Mixture of 85 per cent ethanol and 15 per cent petrol
EIA	Energy Information Administration (US)
EPBB	Expected performance-based buydown
EPG	Ethanol Production Grants
ERI	Energy Research Institute (China)
ERP	Emerging Renewables Program

ETS	Emissions trading scheme
EUA	European Union Allowance
FIT	Feed-in tariff
FY	Fiscal year
g	Gram
GDP	Gross Domestic Product
GEC	Gas Electricity Certificate
GGAS	Greenhouse Gas Reduction Scheme
GSI	Global Subsidies Initiative
GST	Goods and Services Tax
GW	Gigawatt (equal to one thousand megawatts)
GWh	Gigawatt hour (equal to one thousand megawatt hours)
IEA	International Energy Agency
IEEJ	Institute of Energy Economics, Japan
ISO	Independent system operator
ITC	Investment Tax Credit
KCER	Korea Certified Emission Reduction
KEEI	Korean Energy Economics Institute
KEPCO	Korean Electric Power Corporation
kt	Kilotonne (equal to one thousand tonnes)
KRW	South Korean Won
kW	Kilowatt (equal to one thousand watts)
kWh	Kilowatt hour (equal to one thousand watt hours)
L	Litre
LCA	Life-cycle assessment
LEC	Levy Exemption Certificate
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
LRMC	Long-run marginal cost
LSS	Large Substitute for Small

MAC	Marginal Abatement Cost
MED	Ministry of Economic Development (New Zealand)
MEPS	Minimum energy performance standards
MMA	McLennan Magasanik Associates
MPCCC	Multi-Party Climate Change Committee
Mt	Megatonne (equal to one thousand kilotonnes)
ML	Megalitre
MJ	Megajoule
MW	Megawatt (equal to one thousand kilowatts)
MWh	Megawatt hour (equal to one thousand kilowatt hours)
NDRC	National Development and Reform Commission (China)
NEDC	New European Drive Cycle
NEM	National Electricity Market
NGAC	NSW Greenhouse Abatement Certificate
NSEP	National Scheme of Extensive Pilot Projects on Bioethanol Gasoline for Automobiles
NSHP	New Solar Homes Partnership
NSW	New South Wales
NYSERDA	New York State Energy Research and Development Authority
NZU	New Zealand Unit
OECD	Organisation for Economic Co-operation and Development
PBI	Performance-based incentive
PC	Productivity Commission
PTC	Production Tax Credit
PV	Photovoltaic
REC	Renewable Energy Certificate
RES	Renewable Energy Standard
RES Act	Renewable Energy Sources Act
RET	Renewable Energy Target
RFS	Renewable Fuel Standard

RGGI	Regional Greenhouse Gas Initiative
ROC	Renewable Obligation Certificate
RPS	Renewable Portfolio Standard
RTC	Renewable Tax Credit
RTFO	Renewable Transport Fuels Obligation
RTO	Regional transmission operator
SGIP	Self Generation Incentive Program
t	Tonne
TGP	Terminal gate price
TWh	Terawatt hour (equal to one thousand gigawatt hours)
USEPA	United States Environmental Protection Agency
VAT	Value-added Tax
VIU	Vertically-integrated utility
W	Watt
WCI	Western Climate Initiative
WEP	Wholesale electricity price

OVERVIEW

Key points

- More than 1000 carbon policy measures were identified in the nine countries studied, ranging from (limited) emissions trading schemes to policies that support particular types of abatement technology.
  - As policies have been particularly targeted at electricity generation and road transport emissions, the Commission analysed major measures in these sectors.
- While these disparate measures cannot be expressed as an equivalent single price on greenhouse gas *emissions*, all policies impose costs that someone must pay. The Commission has interpreted 'effective' carbon prices broadly to mean the cost of reducing greenhouse gas emissions — the 'price' of *abatement* achieved by particular policies.
- The Commission's estimates essentially provide a snapshot of the current cost and cost effectiveness of major carbon policies.
  - The subsidy equivalent, abatement achieved and implicit abatement subsidy have been calculated for policies and aggregated by sector in each country.
- As a proportion of GDP, Germany was found to have allocated more resources than other countries to abatement policies in the electricity generation sector, followed by the UK, with Australia, China and the US mid-range.
- Estimates of abatement relative to counterfactual emissions in the electricity generation sector followed a similar ordering, with Germany significantly ahead, followed by the UK, then Australia, the US and China.
- The estimated cost per unit of abatement achieved varied widely, both across programs within each country and in aggregate across countries.
  - Emissions trading schemes were found to be relatively cost effective, while policies encouraging small-scale renewable generation and biofuels have generated little abatement for substantially higher cost.
- The relative cost effectiveness of price-based approaches is illustrated for Australia by stylised modelling that suggests that the abatement from existing policies for electricity could have been achieved at a fraction of the cost.
  - However, the estimates cannot be used to determine the appropriate starting price of a broadly-based carbon pricing scheme.
- The estimated price effects of supply-side policies have generally been modest, other than for electricity in Germany and the UK.
  - Such price uplifts are of some relevance to assessing carbon leakage and competitiveness impacts, but are very preliminary and substantially more information would be required.

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- The estimated price effects of supply-side policies have generally been modest, other than for electricity in Germany and the UK.
  - Such price uplifts are of some relevance to assessing carbon leakage and competitiveness impacts, but are very preliminary and substantially more information would be required.

Overview

The Australian Government asked the Productivity Commission to undertake a research study into effective carbon prices that result from emissions-reduction policies in Australia and other key economies (box 1). It is one of a suite of studies that the Australian Government has commissioned to help it, and a Multi Party Climate Change Committee it has formed, consider various issues concerning the introduction of a carbon price in Australia.

By providing information about the extent of climate action in key economies and sectors, it was anticipated that this study would shed some light on Australia's mitigation effort relative to other selected countries. In addition, by estimating impacts of mitigation policies on particular sectors such as electricity generation, it could assist in assessing potential impacts of Australia's policy actions on the international competitiveness of domestic emission-intensive trade-exposed industries.

In addition to Australia, the countries covered by this study are: China, Germany, India, Japan, New Zealand, South Korea, the United Kingdom and the United States. These countries are taking action to address climate change in various ways. Some have introduced emissions trading schemes (ETSs), and all have in place a range of more limited, less direct measures, such as mandatory renewable energy targets, feed-in tariffs, energy-efficiency measures and capital subsidies for constructing or installing sources of renewable energy.

All of these measures either encourage abatement or discourage emissions of greenhouse gases. They essentially alter relative prices to favour production and consumption of low-emissions products over high-emissions ones. While this might suggest that they can be expressed in terms of either explicit or implicit carbon prices, there is no carbon price equivalent that can capture the nature, amount and costs of abatement, nor the product price impacts, resulting from schemes that promote particular forms of abatement.

What all schemes do have in common is that they involve a cost (which someone must pay). These costs can be expressed in subsidy equivalent or resource cost terms, and can loosely be thought of as the 'price' of *abatement* achieved by

particular policies. They have accordingly been the focus of the Commission's analysis.

Box 1 **What the Commission has been asked to do**

The terms of reference require the Commission to:

- examine and detail key emissions-reduction policies either in place or 'committed' in Australia and other key economies
- estimate the 'effective carbon price' per tonne of carbon dioxide equivalent (carbon) emissions faced by the electricity generation sectors in these economies, and selected industries drawn from manufacturing and transport sectors in these and other countries, where relevant and data permitting
- report on the methodology, assumptions and data sources used, so as to inform further analysis in this area.

What are the study countries doing?

The first part of the task was to compile a comprehensive list of measures adopted or proposed in each country. These country 'stocktakes' were not confined to policies in particular sectors, although in practice the bulk of them target emissions from the electricity generation and transport sectors.

Applying a broad interpretation of emissions-reduction policies (table 1), the Commission identified over 1000 measures in total, with more than 300 in the United States (federal and state), around 230 in Australia and 100 in the United Kingdom. While sheer numbers of policies say nothing in themselves about the materiality or effectiveness of the aggregate response made by governments, they indicate how complex the policy environment can be and, particularly in federal systems, the potential for overlapping policies with high administration and compliance costs.

While most policies focus to varying degrees on emissions from electricity generation and transport sectors, other sectors are commonly targeted as well. For example, most countries were found to have policies encouraging reafforestation or curbing deforestation.

Table 1 **A taxonomy of existing emissions-reduction policies**

Explicit carbon prices	***Regulatory instruments***
Emissions trading scheme — cap-and-trade	Renewable energy target
Emissions trading scheme — baseline and credit	Renewable energy certificate scheme
Emissions trading scheme — voluntary	Electricity supply or pricing regulation
Carbon tax	Technology standard
Subsidies and (other) taxes	Fuel content mandate
Capital subsidy	Energy efficiency regulation
Feed-in tariff	Mandatory assessment, audit or investment
Tax rebate or credit	Synthetic greenhouse gas regulation
Tax exemption	Urban or transport planning regulation
Preferential, low-interest or guaranteed loan	Other regulation
Other subsidy or grant	***Support for research and development (R&D)***
Fuel or resource tax	R&D — general and demonstration
Other tax	R&D — deployment and diffusion
Direct government expenditure	***Other***
Government procurement — general	Information provision or benchmarking
Government procurement — carbon offsets	Labelling scheme
Government investment — infrastructure	Advertising or educational scheme
Government investment — environment	Broad target or intergovernmental framework
	Voluntary agreement

Several countries have introduced or have committed to emissions trading schemes

Among the study countries, the United Kingdom and Germany are part of the European Union's cap-and-trade ETS — which commenced in 2005 — and New Zealand introduced its own scheme in 2008.

- The EU scheme covers power stations, combustion plants, oil refineries and iron and steel works (but not road transport fuels). It will extend to the aviation sector in 2012 and petrochemicals, ammonia and aluminium in 2013. In May 2011, the spot price for permits was around €16–17 (A$22–23).
- The NZ scheme covers electricity generation, industry, liquid fossil fuels and forestry, and is expected to expand coverage to agriculture by 2015. Currently, emissions are uncapped.

Japan and South Korea have announced that they will introduce ETSs (although in both cases implementation has been delayed). China is considering trialling a pilot ETS in some provinces as part of its 12th Five Year Plan. The Australian Government has recently announced its intention to introduce an ETS that will commence with fixed price permits moving to a floating price in three to five years.

There are also sub-national ETSs in place or proposed. The Regional Greenhouse Gas Initiative covers electricity in 10 states in the north east of the United States (but the cap is not currently binding). The Western Climate Initiative was intended to cover seven US states and four Canadian provinces. It aims to reduce emissions to 15 per cent below 2005 levels by 2020. But, it appears that only California among the US states is committed to implementing an emissions trading scheme by 2012. Another example is the New South Wales Greenhouse Gas Reduction Scheme, which is a baseline and credit scheme applying to its electricity sector.

There is a myriad of policy measures in the electricity generation sector

The most widely applied emissions-reduction policies are mandatory renewable energy targets (most with tradeable permits), feed-in tariffs, and capital subsidies (often in conjunction with feed-in tariffs).

- Mandatory renewable energy targets apply at the national level in Australia, Germany and the United Kingdom (under an EU mandate), Japan, and South Korea (committed for 2012). China has an 'aspirational' target only. Although the United States does not have a national level mandatory renewable energy target, over 41 states have renewable targets of one form or another, most mandatory.
- Feed-in tariffs apply at a national level in Japan, the United Kingdom, South Korea and Germany, and at a state level in Australia. China and India operate national and state/province-based schemes. Feed-in tariffs also exist in some US states, where they operate mainly as commercial arrangements between utilities and small-scale generators that the utilities use to meet their renewable energy targets. New Zealand does not currently use feed-in tariffs.
- Capital subsidies are common and provided for widely varying purposes, from assisting in the provision of large-scale generation capacity, to helping individual households and small businesses install small-scale generation.

Other policies being used to a lesser extent included fossil fuel taxes (Japan and India), differentiated electricity taxes (United Kingdom), and preferential loans for investment in renewable generation.

Fuel policies are widely used to reduce road transport emissions

Countries seek to reduce emissions in the road transport sector primarily through fuel taxes, production subsidies for biofuels, vehicle fuel efficiency standards and/or labelling, fuel mandates, and differentiated vehicle taxes and subsidies.

Study countries also employ a range of other transport policies (such as urban planning and transport infrastructure funding) that may less directly effect emissions reductions. For example, transport infrastructure policies, such as those that encourage modal shifts in activity from road to rail, are sometimes publicly justified in part by their potential for reducing emissions. Similarly, road congestion pricing, which is largely an instrument for containing traffic flow and reducing travel times, might also yield local environmental benefits as well as possible reductions in carbon emissions.

The Commission's analytical approach

The threshold conceptual task for this study has been to develop a consistent measurement approach for comparing many different policy interventions — in essence, finding a way of comparing apples and oranges. Understanding how the various policies work was the essential first step.

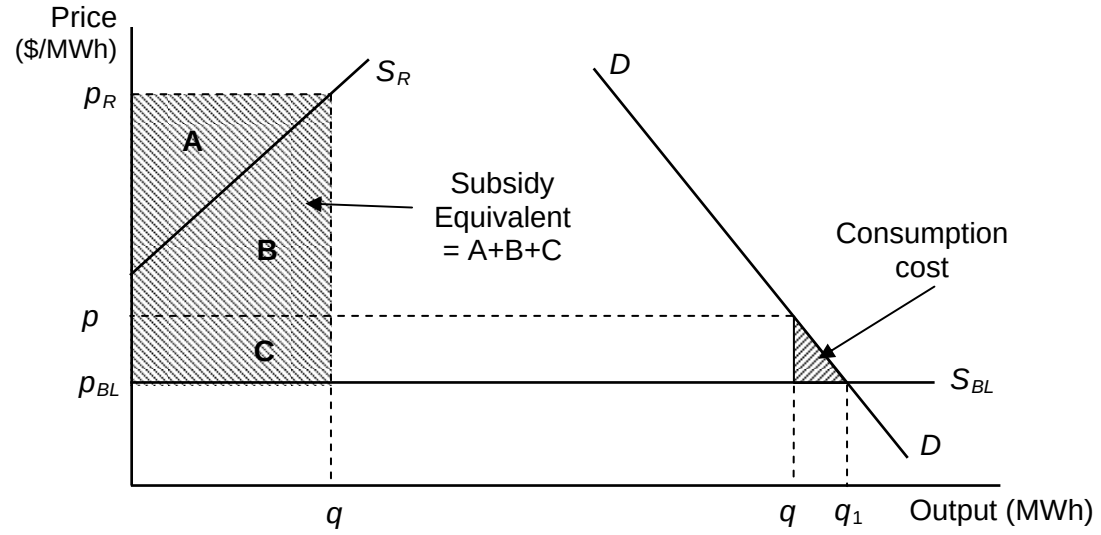
Despite the variety of specific policy instruments, all emissions-reduction policies can be classified as those that either:

- penalise consumption of high-emissions products
- encourage production of low-emissions ones (box 2 shows diagrammatically how such schemes work).

But whichever side of the market particular policies target, they will have implications for the other side. Policies that effectively tax one commodity implicitly subsidise others. And effective subsidisation of a commodity implicitly taxes others.

A carbon pricing mechanism, for example, raises the price of products generating carbon emissions (thus reducing demand for those products) while, at the same time, effectively subsidising production of low-emissions substitutes, by increasing the price that can be charged in the market. A carbon pricing mechanism will therefore give rise to a wide range of responses generating abatement, based on consumer and producer assessments of the relative costs and benefits to them. It is this market-based objective assessment of the costs and benefits of abatement options that underpins why direct pricing mechanisms generally will deliver any given amount of abatement at least cost.

Box 2 **How subsidies and renewable energy targets work**



This figure is a stylised representation of an electricity generation market, with emissions-intensive, baseload electricity being provided at a constant unit cost equal to price p_{BL}, pre-intervention. Total consumption is q_1. Introducing a mandatory renewable energy target will induce abatement on the supply and demand sides, but at a cost.

On the supply side it is assumed above that the mandatory renewable energy target will induce supply from a mix of generators using zero-emissions technologies including, for example, wind and solar. As some of these facilities will be more costly than others, the supply curve is shown as the upward sloping line S_R. If the renewables target is set at quantity q_R, the price required by marginal generators will be p_R.

- The implicit subsidy paid per megawatt hour (MWh) to renewables producers is $p_R - p_{BL}$, and the subsidy equivalent is equal to the shaded area A+B+C. Abatement would be equal to the difference in emissions intensities of the baseload generator and the renewables generators (the latter being zero in this case), multiplied by the amount of renewable electricity q_R.
- Part of the subsidy equivalent, area A, is 'producer surplus' to renewables generators — the size of this depends on the excess of the price received over their costs of production. The remainder (areas B+C), is the additional *resource cost* of supplying q_R (that is, additional to the cost of the baseload generation being replaced).

On the demand side there will also be some abatement and cost to consumers, if the cost to electricity retailers (which is equal to the subsidy equivalent) is passed through in prices. As depicted, the electricity price rises from p_{BL} to p inducing a reduction in consumption of (fossil fuel sourced) electricity equal to $q_1 - q$, and some additional abatement. It also means that there is a cost equal to the shaded triangle labelled *consumption cost*. This measures the *net* consumer valuation of the forgone consumption.

Many other emissions-reduction policies instead directly support use of low or zero-emissions technologies or production of 'cleaner' products. Sometimes this is done through explicit budgetary subsidies. More common mechanisms are mandated targets or regulation. In these cases, the transfers to producers of certain products or technologies are less transparent. Whether the subsidies are explicit or implicit, the effect in terms of increasing payments to induce additional production from targeted producers is the same (the subsidy equivalent is illustrated by the shaded rectangle in box 2).

Where schemes differ is in relation to who ends up paying for them — taxpayers who pay for explicit budget subsidies, or households and firms who pay the increased product costs due to regulations and mandates. Where users pay, the policies will also generate some 'demand-side' abatement and impose a consumption cost.

A carbon price cannot mimic all the effects of a subsidy scheme

While both carbon pricing mechanisms and more targeted abatement policies work by changing relative prices, they change *different* relative prices. Finding a price-based metric for comparing diverse emissions-reduction policies across countries is elusive. While all such policies can in principle be captured in terms of a subsidy that would have equivalent effects, they cannot be similarly summarised as a price or tax rate. In other words, there can be no carbon tax that could achieve the same abatement, with the same cost and consumer price effects, as measures that do not directly price or tax carbon.

That a carbon price cannot mimic a policy that just subsidises a particular form of abatement is shown in the four examples relating to renewable energy policies set out in box 3. In effect, there are several different carbon price 'equivalents', with each replicating a different aspect of a subsidy scheme. These measures yield useful insights (particularly the carbon price that will deliver the same abatement at lowest cost). But they are also sometimes represented as comparable effective carbon prices, which they are not.

Box 3 **The elusive 'implicit' carbon price**

There are a number of different carbon prices that could capture a particular aspect of the impacts of a subsidy scheme, but none can replicate all aspects.

- First, there will be a carbon price/tax (equal to the subsidy rate) that could induce the same amount of renewable energy as a renewables subsidy, but it would likely generate greater abatement overall.
- Second, there will be a carbon price/tax that would generate the same resource costs as the subsidy scheme, but this would generate a different type and level of abatement (depending on the coverage of the carbon price mechanism).
- Third, there will be a carbon price/tax that would deliver the same total amount of abatement as the renewables subsidy, but from the lowest-cost sources.
- Fourth, there will be a carbon price/tax that would deliver the same *average* increase in electricity prices as a renewables subsidy (assuming that the subsidy is paid for by electricity consumers rather than by taxpayers). But this carbon price would be too low to support the renewable production brought forth by the subsidy.

What the Commission has estimated

While there is no one carbon price 'equivalent' that would comprehensively capture what the set of policies in the study countries are actually achieving, or at what cost, all policies (carbon pricing mechanisms and explicit or implicit subsidy schemes) impose costs that ultimately someone must pay. These costs of abatement can be compared. Accordingly, the Commission has measured:

- what each country is effectively spending on abatement programs; that is, the subsidy 'equivalent' of policies. These subsidy equivalents also provide an (upper) indication of the resource costs of the policy (which are much harder to estimate directly)
- the amount of abatement being achieved
- the average implicit abatement subsidy (that is, the subsidy per unit of abatement).

The Commission has also measured the costs of any abatement from higher consumer prices resulting from the suite of policies analysed in each country.

Which policies?

The Commission analysed policies applying to road transport in addition to electricity generation. Like electricity generation, road transport is an important upstream input for most if not all industries and it has direct impacts on consumers. It also attracts a number of specific emissions-reduction policy measures.

Emissions associated with electricity generation and transport account for around half of Australia's emissions. While manufacturing industries were not specifically covered, they are substantial users of emissions-intensive products — particularly electricity but also road transport. Hence, the study effectively covers a significant proportion of abatement policies relevant to manufacturing. This is particularly so for emissions-intensive trade-exposed industries that have a high reliance on electricity, such as aluminium production. Moreover, there appear to be relatively few emissions-reduction policies specific to manufacturing industries in the countries studied.

Policy choice was also influenced by the requirement to examine 'committed' policies, interpreted as those having tangible evidence of being implemented — for example, in the process of being enacted. In practice, it proved difficult to quantify many committed policies because of a lack of detail about their eventual operation and coverage.

Policy measures were screened against several criteria, including that they penalise emissions or give an incentive to abatement, and that they do so in a reasonably direct way. A materiality test was also imposed, though as information began to accumulate some policies initially considered material turned out to be otherwise, and vice versa.

While policies that had the *effect*, if not the explicit intent, of reducing emissions were not necessarily excluded, for inclusion, policies needed to impose additional costs. This effectively excluded 'no regrets' measures; that is, policies that would have been undertaken regardless of their impact on greenhouse gas emissions to achieve domestic objectives (such as revenue raising or reducing local pollution). In such cases, the marginal costs of any associated 'by-product' abatement can be negligible. Inevitably though, some policies fell into a grey area, such as China's 'Large Substitute for Small' (LSS) generator modernisation program, which is discussed further below. For policies with multiple objectives, in most cases it was not possible to decompose abatement estimates (or for that matter costs), and sensitivity analysis has been used to capture the range of possible outcomes.

Based on these criteria, policies such as explicit carbon prices, taxes on fossil fuels and electricity production or consumption, feed-in tariffs for renewable energy production and renewable energy mandates (with or without certificates/credits), capital subsidies for investment in renewables, and biofuel content standards for transport fuels were generally included. Although the selected policies typically represent only a small proportion of the total policies that exist in each country, the Commission is reasonably confident that it has captured those that have induced the bulk of each country's abatement in these sectors.

That said, some significant classes of policy, including energy efficiency programs, research and development support, and transport infrastructure expenditures, were excluded, for largely pragmatic measurement reasons outlined in box 4.

Box 4 Why were some key policies excluded?

Research and development policies were excluded because it was considered that the connection between the policy and the eventual emissions reduction that might be achieved (and cost incurred for that matter) was prospective and therefore too uncertain. Given the Government's apparent interest in assessing comparable effort, the Commission has primarily focused on what policies are in place and having effect already.

Energy and fuel efficiency policies are widely employed by most study countries, and generally regarded at least in part as emissions-reduction measures. But measuring their impacts is complex and uncertain. Some claim that these policies are privately cost effective (that is, they make consumers better off) and thus lead to abatement at a negative cost (benefit). Others claim it is more likely that such policies override consumer preferences leaving them worse off. Depending on the assumptions made, the costs of such policies could therefore be negative or positive. Measuring abatement of such policies is also fraught. Net abatement will depend not only on the efficiency of appliances and vehicles but also on their use. For instance, studies suggest that when people upgrade to more energy-efficient appliances and vehicles they tend to use them more — a so called 'rebound effect'.

Equally problematic are policies such as public transport and rail freight *infrastructure expenditure*, which also can have extremely complex links to emissions reductions. Net emissions impacts will depend on the degree of modal switching, the effect on total trips and the relative emissions intensity of different transport modes.

Measuring abatement induced by the policy measures

In seeking to measure the abatement achieved under the various policies, it is necessary to know the counterfactual — that is, all else given, what would the level of emissions have been *without* the policy?

In the case of electricity generation, for example, the 'marginal generator' can vary depending on market circumstances, and this can have a substantial impact on the amount of abatement that can be attributed to an abatement policy. For example, if subsidised renewable electricity sourced from wind or solar displaces gas-fired electricity, the abatement achieved will be far less than if coal-fired electricity generation were displaced. Operators will naturally choose to displace higher-cost energy sources before cheaper ones (such as coal) irrespective of the relative emissions intensity of the sources.

Apportioning abatement to particular policies or programs proved difficult where there was overlap between them. For example, in the United States, large-scale renewables are eligible for substantial Federal Government subsidies, but most states also have mandatory renewable energy targets, meaning that the same project can benefit from both programs. Care has been taken to ensure that any induced abatement is only counted once, irrespective of how many policy measures the one project may be eligible for.

Adding it all up

As far as possible, for each policy measure, a subsidy equivalent (as a proxy measure of total costs) and an implicit abatement subsidy per tonne of carbon abated (as a proxy for average costs), are reported. However, as noted, in some cases it has not been possible to isolate the abatement effects of particular measures.

The Commission also aggregated the subsidy equivalent measures to produce an estimate of the total and average abatement subsidy for the electricity generation and biofuel sectors in each country.

These measures facilitate comparison not only of the costs associated with each country's policy mix, but also of the *cost effectiveness* of different measures within and across countries in each sector. They are useful indicators of the extent to which different governments are prepared to devote community resources to encouraging abatement — either directly through explicit financial subsidies paid by taxpayers, or indirectly through higher prices paid by consumers.

The Commission has also provided rough estimates of the increases in product prices potentially attributable to the various supply and demand-side interventions in each sector for each country. Where supply-side measures are directly paid for by consumers, the subsidy equivalents for all measures were added together before estimating the increase in product price. In the United Kingdom, Germany and New Zealand this total includes the revenue raised from the electricity sector through the respective ETS schemes operating in those countries. The impact on the prices of electricity and transport fuels is of policy interest in itself, given the link to competitiveness of end users.

Key results

The following sections present the estimates for electricity generation and road transport (biofuels and fuel taxes) from the supply-side and demand-side perspectives. For the supply-side analyses, it should be kept in mind that the subsidy equivalent figures will tend to overestimate resource costs — potentially by a factor as high as two — but on the reasonable presumption that that they do so consistently for all countries and all low-emissions technologies, the *comparative* picture is not affected. (It should be noted that the Indian Government ultimately chose not to participate in this study, so that no estimates could be made for that country.)

Most estimates are based on 2010 data, but in some cases 2009 or 2008 data were the latest available. In essence, the estimates provide a recent 'snapshot' of the impacts of policies in that year (that is, relative to the counterfactual of not having the policy). As this policy space is highly dynamic, a different picture could emerge in a relatively short period. For example, many policies seek to influence investments, with ramifications for abatement in years to come.

Electricity generation

Supply-side measures

The key estimates for the electricity generation sector are summarised in table 2.

Table 2 **International comparisons, electricity generation sector**

Results in A$ 2010

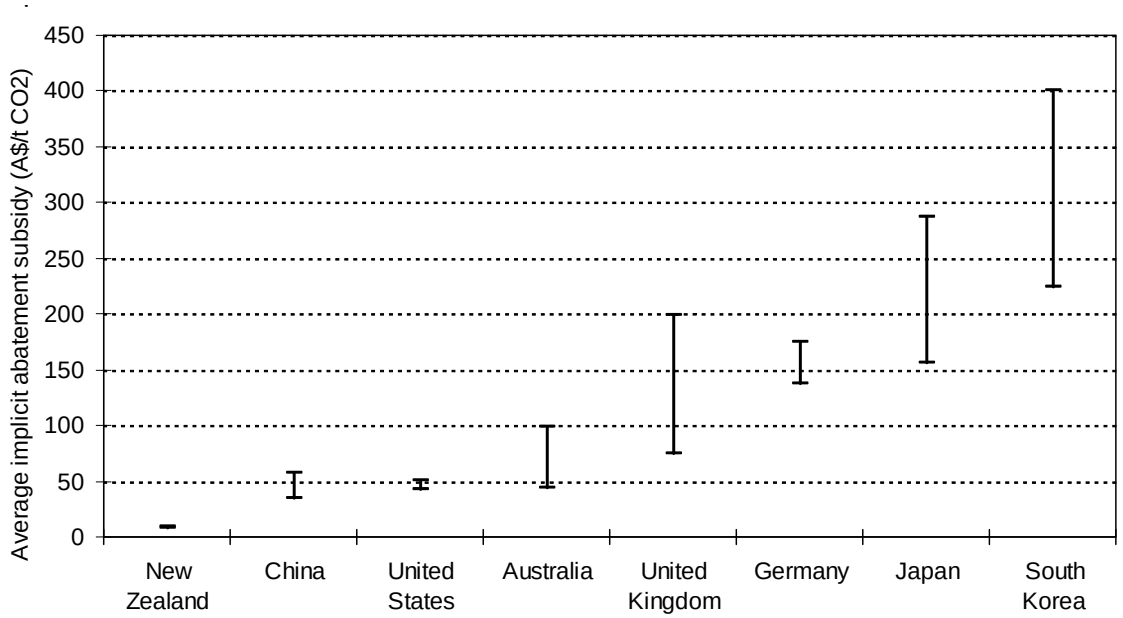
Country	*Total subsidy equivalent*	*Total subsidy equivalent as a percentage of GDP*	*Total abatement*	*Abatement as a percentage of counterfactual electricity sector emissions*	*Total electricity sector emissions*	*Average Implicit abatement subsidy*	*Electricity price uplift*
	A$m	%	Mt CO_2	%	Mt CO_2	A$/t CO_2	%
Australia	473–694	0.04–0.05	7.0–10.7	3.5–5.2	196	44–99	1–2
China	1 835–2 309	0.03–0.04	40.7–52.1	1.2–1.5	3 370	35–57	1
China including abatement from LSS	1 835–2 309	0.03–0.04	159.2–225.6	4.5–6.3	3 370	8–15	..
US	2 886–3 339	0.02–0.02	66.5–66.7	2.8–2.9	2 270	43–50	–
UK	2 042–2 433	0.08–0.10	12.3–27.4	7.5–15.4	151	75–198	17
EU ETS coal/gas switch	115–403	0.00–0.02	4.0–14.1	2.6–8.5	151	29	..
UK excluding all ETS effects	1 648–1 752	0.07–0.07	8.2–13.3	5.2–8.1	151	124–213	..
Germany	10 019–11 769	0.28–0.33	67.1–73.1	18.3–19.6	299	137–175	12–14
EU ETS coal/gas switch	15–80	0.00	0.7–3.9	0.2–1.3	299	20	..
Germany excluding all ETS effects	9 868–11 553	0.28–0.32	66.4–69.1	18.2–18.8	299	143–174	..
Japan	669–940	0.01–0.02	3.3–4.3	0.8–1.1	396	156–287	1
South Korea	313–379	0.03–0.03	0.9–1.4	0.5–0.7	191	225–401	–
New Zealand	..	..	..	..	..	8–10	1–2

While there will likely be a focus on the implicit abatement subsidy estimates, these are not carbon price equivalents of the policies in place (and, for the reasons outlined earlier, nor can they be converted into price equivalents). Furthermore, a high or low implicit abatement subsidy in isolation cannot be interpreted as good or bad — it must be considered in conjunction with both the amount of abatement achieved and the cost of achieving it.

- Australia's electricity generation sector's average implicit abatement subsidy was comparable to estimates for China (excluding China's 'Large Substitute for Small' program) and the United States (using the lower bound estimates the numbers are A$44, A$35 and A$43/t CO_2 respectively) (figure 1)
- Australia's abatement as a proportion of total electricity sector emissions (presumed to occur in the absence of these measures) was estimated to be higher than for China (depending on policy coverage), Japan and South Korea, broadly comparable with the United States, and lower than the United Kingdom and Germany.

Figure 1 **Implicit abatement subsidies vary widely for electricity generation**

2009, 2010



- Although the United Kingdom and Germany achieved more abatement than Australia (in absolute terms and relative to electricity sector emissions), they did so at a substantially higher cost, both absolutely and relatively. For example, using the lower bound estimates, Germany achieved around 67 Mt of abatement, with a total subsidy equivalent of approximately A$10 billion and an implicit abatement subsidy of A$137/t CO_2. The comparable figures for Australia are 7 Mt of abatement, a total subsidy equivalent of A$473 million and an implicit abatement subsidy of A$44/t CO_2.
- That high implicit abatement subsidies are not necessarily a guide to effectiveness is clearly illustrated by South Korea and Japan. These countries have the highest unit subsidies, but their abatement has been very modest — as a proportion of electricity sector emissions, the lowest of the study countries.
- The results for the United States are probably underestimated. They are based predominantly on two key federal programs (Renewable Electricity Production Tax Credits and the Treasury Grants) and state renewable energy mandates. There are many other programs in operation (particularly in individual states), and it was not possible to quantify the impact of all of them in the time available. The United States has also announced an intention to regulate major emissions sources directly under standards to be introduced under the Clean Air Act (US), but the timing and effect is uncertain.
- The co-existence of the European Union's ETS with other national measures appears to have had quite different effects on the results for the United Kingdom and Germany.
  - In the United Kingdom, the ETS appears to have led to some switching from high-emissions coal to lower-emissions gas-fired electricity. This yielded substantial abatement. If the effects of the European Union ETS are removed from the United Kingdom estimate, aggregate abatement falls by as much as a half, and the total subsidy equivalent by around 20 per cent. The net effect is to increase significantly the implicit abatement subsidy estimate for the remaining policies.
  - If the effects of the European Union ETS are excluded from Germany's results, both the aggregate abatement and the total subsidy equivalent fall slightly. The net effect on the average implicit abatement subsidy is also negligible. The reason is that Germany has had limited surplus gas-fired generation capacity, and hence relatively little fuel switching. By contrast, renewables constitute a relatively large share of Germany's electricity generation sector, and receive generous subsidies. In aggregate, the effects of the ETS are swamped by the very high subsidies to renewables. Hence, in

contrast to the United Kingdom, excluding the ETS from Germany's results has little effect on the estimates.

- The results for China depend very much on whether its 'Large Substitute for Small' program of modernising its electricity generation plants is included in the analysis. If it is, the implicit abatement subsidy under the low scenarios falls from A$35/t CO_2 to A$8/t CO_2. Under reasonable assumptions, the replacement of old inefficient generators with new, larger and much more efficient generators seems to be cost effective in its own right. This means that the cost impacts are negligible or negative if the 'Large Substitute for Small' is classified as an emissions-reduction policy (a 'no regrets' measure). In other words, including this policy adds considerable abatement at no cost. But this could be regarded as an incidental outcome of a policy that is seemingly justifiable on the grounds of reducing generation costs (and most probably also promoting local environmental objectives). In a more market-based economy, such cost-reducing generation replacement would be expected to occur automatically and thus would not have been considered an emissions-reduction policy.

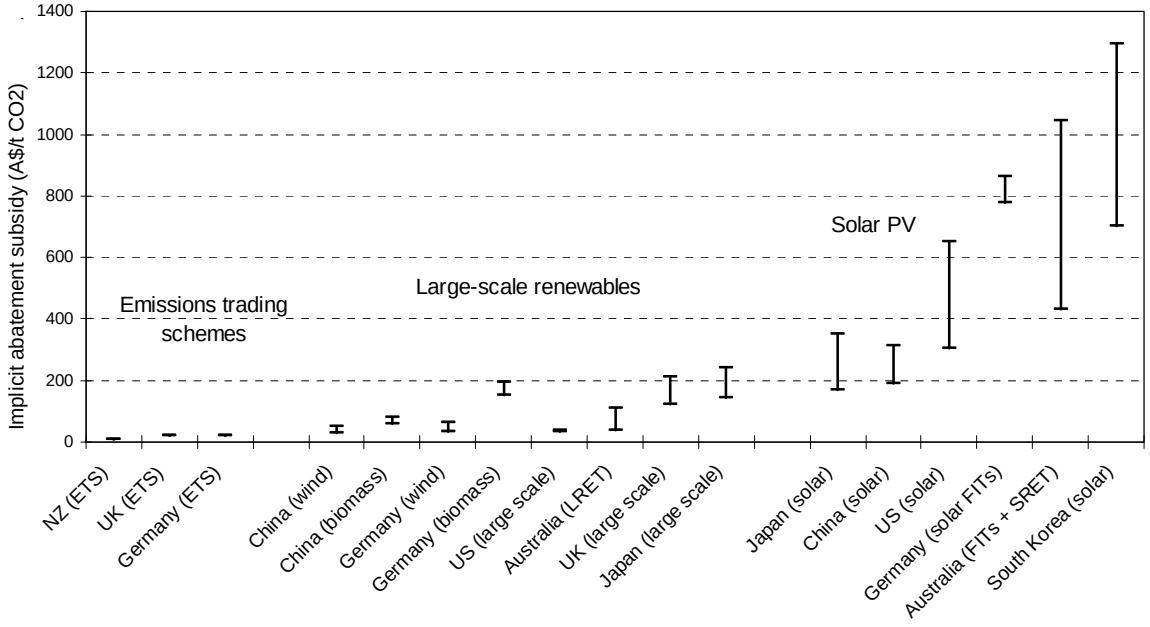
Overall, key insights to emerge are that the European Union ETS has driven relatively low-cost abatement, where it has induced switching from coal to gas-fired electricity generation. Policies supporting renewable energy sources are more expensive, reflecting the higher costs of large-scale renewables production and particularly small-scale solar technology, which was found to be very expensive in all countries examined (figure 2).

Demand-side analysis

Measuring consumption costs requires knowledge of how demand responds to changes in price, and how much of the subsidy is actually passed through in product prices. There is little empirical information as to how these factors will vary from one country to another. In some countries, notably China, retail price regulation limits the ability of electricity suppliers to pass on costs, so the consumption effects may be negligible, at least in the shorter term. The Commission has accordingly had to make some simplifying assumptions about demand responsiveness and cost pass-through to provide indicative results in this area. Two alternative elasticities were used to estimate the range within which demand responses seem most likely to occur, based on empirical evidence of the responsiveness of demand to price changes.

Figure 2 **Implicit abatement subsidies by technology and country**

Electricity generation, 2009, 2010



The estimated impact of emissions-reduction policies on electricity prices and thus on consumption costs varies considerably across countries. For most countries, the estimated impacts are small. This is partly because the renewable energy generation induced by the policy measures is a small proportion of total electricity generation, and/or the total subsidy equivalent estimate is not large. For example, for Australia, the impacts on electricity prices in 2010 were estimated to be of the order of one to two per cent, and the consumption cost is estimated to be in the range A$2–3/t CO_2 abated. (Recent changes to the Renewable Energy Target are expected to lead to larger increases.)

The key exceptions are Germany and the United Kingdom, where it is estimated that existing emissions-reduction policies have raised electricity prices by 12 and 17 per cent, and reduced emissions by 3 and 19 per cent, respectively. This is due partly to the direct price impact of the European Union ETS on retail prices, and partly to the large subsidy equivalents associated with other measures promoting renewable energy paid for by consumers. As a result, the estimates of consumption costs are commensurately much larger than in other countries, though still less than the implicit abatement subsidies discussed above.

A general finding from these results is that if demand is responsive to price, additional and relatively low-cost abatement can be achieved from electricity price increases. (Indeed, the incentive provided for demand-side abatement is a major reason for the relative cost effectiveness of carbon pricing mechanisms.)

Road transport

Abatement costs were estimated for biofuel policies and fuel taxes — biofuels on the supply side and fuel taxes on the demand side. Fuel taxes are levied for a variety of reasons, but because they act reasonably directly on a key source of emissions (fossil fuels used by vehicles) they can be considered a form of carbon tax. Multiple objectives are also a feature of biofuel policies in many countries. Though typically portrayed as an emissions-reduction measure, biofuel policies have also been used for industry assistance reasons and regional development reasons. (In China, for a time in the early 2000s, it was an opportune way of using stale grain stocks.)

Supply-side analysis of biofuels

Biofuels contribute to emissions reductions by replacing fossil fuels. Carbon sequestered in the biofuel is released back into the atmosphere once combusted, but there can be a net gain compared with using petrol and diesel. However, *net* emissions reductions will depend on the emissions intensity of the production processes used to grow the crop, manufacture the biofuel and deliver it to consumers, as well as the choice of feedstock, as some are much more emissions-intensive than others. This is why life-cycle analysis is needed to properly compare the net emissions from biofuels relative to the fossil fuel alternative. In some cases, the estimated gains are very small and possibly negative.

Analysing the key policies for each country indicates that Australia's implicit abatement subsidy for biofuels was similar to the United Kingdom, Germany and New Zealand but substantially less than was estimated for the United States. However, costs and abatement varied widely across these countries (table 3).

- The United Kingdom, Germany and the United States — all with fuel content mandates — had high total subsidy equivalents and abatement.
  - Germany stands out as having achieved the highest abatement relative to emissions for the road transport sector (3.6 per cent), at an implicit abatement subsidy of more than A$300/t CO_2, which nevertheless was at the lower end of the results for all countries.
  - The United States stands out for substantial abatement but at very high cost — with the implicit abatement subsidy estimated to be in the range of A$604–672/t CO_2.
- New Zealand committed a very small amount of resources to biofuels and hence was achieving very little abatement.

Table 3 **International comparisons, biofuel policies**

Results in A$(2010)

	Total subsidy equivalent			*Total abatement*			*Total abatement as a percentage of counterfactual road transport emissions*			*Implicit abatement subsidy*		
Country	*Low*	*Central*	*High*	*Low*	*Central*	*High*	*Low*	*Central*	*High*	*Low*	*Central*	*High*
	A$m	A$m	A$m	Mt CO_2-e	Mt CO_2-e	Mt CO_2-e	%	%	%	A$/t CO_2-e	A$/t CO_2-e	A$/t CO_2-e
Australia	..	144	..	..	0.4	..	..	0.6	..	..	364	..
China	1 998	1 998	1 998	..	..	..	..	..	..	..	..	..
Ethanol	..	..	..	-1.4	-0.3	0.8	-0.43	-0.09	0.24	..	-6 105	..
Biodiesel	..	..	..	..	0.2	..	..	0.05	..	..	592	..
Germany	..	1 711	..	..	5.5	..	..	3.6	..	..	310	..
Japan	57	57	57	0.092	0.090	0.087	0.044	0.043	0.042	617	634	653
New Zealand	..	3	..	..	0.008	..	..	0.06	..	..	391	..
South Korea	196	196	196	0.5	0.3	0.2	0.6	0.4	0.3	415	635	831
United Kingdom	..	680	..	..	2.0	..	..	1.7	..	..	335	..
United States	12 470	17 477	..	..	26	19	..	1.7	1.2	604	666	672

Japan and South Korea had relatively high cost biofuel schemes that achieved minimal abatement.

The results for China suggest that only under the most favourable assumptions could its biofuel policies have been achieving net abatement. Under more plausible scenarios, the net abatement was negative. This amounts to China having subsidised emissions rather than abatement. This result appears to be due to the high application of fertiliser to grow feedstock for ethanol, and the high level of energy use to convert feedstock into fuel.

In summary, while the results for biofuels vary, and are particularly sensitive to assumptions about life-cycle emissions intensities, most biofuel policies are high-cost means of achieving abatement. The cost per tonne of abatement — as measured by the implicit abatement subsidy — was typically A$300–600/t CO_2 and possibly as high as A$800/t CO_2. For most countries, this cost is substantially higher than for most supply-side measures in electricity generation (though broadly comparable with solar subsidies).

Fuel mandates and taxes

The Commission has explored the impact of a key supply-side policy measure on retail fuel prices, namely the fuel mandates operated by the United States, Germany and the United Kingdom. These tend to increase fuel prices by the requirement placed on fuel distributors to blend more costly biofuels into petrol and/or diesel. However, the Commission's results suggest that, to date, the mandates appear to have had only a modest effect on prices, with at most an impact of around 1 to 2 cents per litre on retail prices of petrol and diesel.

Treating fuel taxes as carbon taxes?

If regarded as emissions-reduction measures, the various taxes on fuel such as excise taxes (but excluding broadly-based consumption taxes) have been relatively effective at achieving abatement (table 4). Put another way, in the absence of fuel taxes, emissions from road transport would be significantly higher than they are today.

As for electricity, the Commission has had to make some simplifying assumptions about demand responsiveness. In this case, these assumptions are even more speculative, given the much larger tax-induced changes in price. But even if demand were only mildly responsive to price, it is likely that fuel taxes have led to

substantial abatement relative to the counterfactual of no fuel taxes, mainly because the tax rates are substantial. For example, the 'high' estimates for Germany indicate that abatement relative to the counterfactual of no fuel taxes could have been of the order of 40 per cent. Even under the 'low' scenarios (which assume a more inelastic demand response) most countries would seem to have achieved relatively large amounts of abatement. The consumption costs per tonne of abatement are significant, but lower than the costs of many other sources of abatement. Germany's result underscores that consumption costs rise more than proportionately with the rate of tax.

However, it is arguable whether existing fuel taxes should be categorised as an emissions reductions measure. In most countries such taxes have been raised over many decades for general revenue purposes or as 'road-user charges'. Any resultant abatement could be considered incidental. There are some recent instances of increases in fuel taxes having been justified in part on emissions-reduction grounds, but so far these increments are small relative to the pre-existing tax rates, and some countries have made no such distinction.

Table 4 **Abatement and consumption costs of fuel taxes**
2010

Country	*Average fuel tax*	*Consumption cost*	*Abatement*	*Abatement as a percentage of counterfactual road transport emissions*	*Average consumption cost*
	A$/L	A$m (2010)	Mt CO_2-e	%	A$/t CO_2-e
Australia	0.36	373–1 189	6–21	8–23	57–59
China	0.14	449–1 383	20–68	6–17	20–23
Germany	0.78	3 437–11 492	29–102	17–41	113–119
Japan	0.64	2 238–7 301	21–73	9–26	100–105
New Zealand	0.43	54–174	1–3	7–19	71–73
South Korea	0.50	1 046–3 432	12–41	13–34	83–87
United Kingdom	0.96	3 323–11 125	24–85	17–42	130–139
United States	0.11	1 749–5 421	92–291	6–16	19

Some implications

The Commission's results show that the study countries are each using a wide range of policies, with varying costs and effectiveness. But what can the results tell us about directions for climate policy? In particular, what do they say about comparable effort and impacts on international competitiveness?

Comparing 'effort'

There is significant interest in assessing the relative 'effort' of different countries in mitigating climate change. But effort can be interpreted in different ways.

For some it means how much abatement is being achieved and, relatedly, how much the emissions intensity of a country's production is being reduced. But how much abatement is the right amount for each country? Imposing the same proportionate cut in emissions across all countries would take no account of the costs of those reductions. Efficient global abatement will occur where the marginal costs of abatement are equalised across all countries (at the global carbon price that achieves the desired level of global abatement). This efficient outcome would not deliver the same emissions intensities across economies — countries with high abatement costs would abate relatively less (instead 'buying' cheaper abatement from other countries).

Others measure effort by the total costs countries are prepared to incur in implementing emissions-reduction measures. But as the Commission's estimates highlight, high policy costs are often unrelated to the effectiveness of policies in delivering abatement. If effort were measured in this way, a country that adopted more inefficient abatement measures could be inappropriately given greater credit than others generating more cost-effective abatement.

The Commission's estimates of abatement and abatement costs also need to be carefully interpreted in the context of a country's 'effort'.

- The estimates provide a point-in-time, and necessarily partial, picture of the costs and abatement impacts of key policies in two important emitting sectors. In each country there will be a range of other policies, market developments and individual actions not captured in the estimates that will have an effect on total emissions, positive and negative.
- They are not compared with any desirable 'yardsticks' about what each country should be doing.

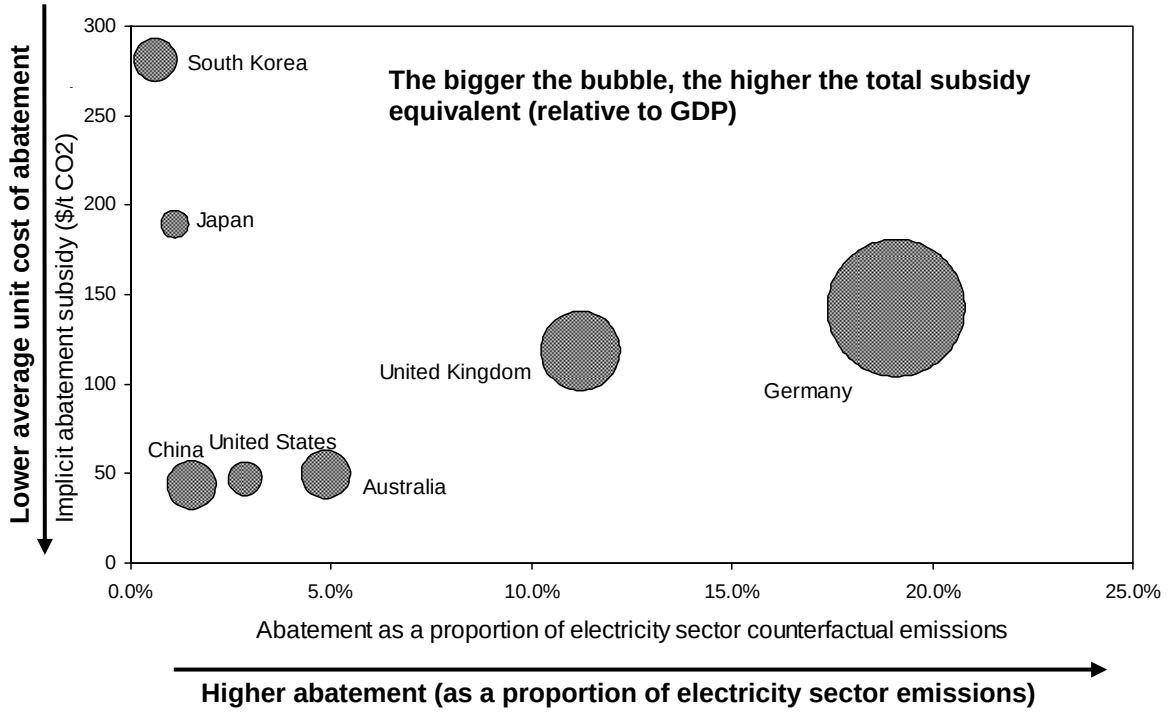
That said, presenting the aggregate estimates in combination, and scaled relative to the size of each country's economy, provides some insights as to their policy performance (figures 3 and 4).

The electricity generation sector

For example, Australia's estimated total subsidy equivalent for the electricity generation sector, expressed as a proportion of GDP (represented by the size of its 'bubble' in figure 3), was much the same as for South Korea and China. But, relative to South Korea, Australia's suite of measures appears to have been much more cost effective and to have produced more abatement. Compared with China, Australia's policies were about as cost effective, but achieved greater abatement. Proportionately, Australia achieved more abatement than the United States at about the same level of cost effectiveness, but devoted more of its GDP to achieving this outcome.

Figure 3 **'Effort' and reward — how countries compare**

Electricity generation 'central' estimates, 2009, 2010



The United Kingdom and Germany stand out as having invested substantial amounts in achieving abatement. Germany achieved substantially more abatement than the United Kingdom but at a slightly higher average cost. The extent to which

that reflects inefficient policy choices or rising marginal costs of abatement is unclear.

Japan also stands out because its investment is much smaller than most other countries and equally is not achieving much abatement. And the abatement it does achieve comes at a high average cost.

Biofuels

Using the same approach for biofuels reveals that, as a proportion of GDP, Australia's commitment of resources to achieving abatement was less than for most other study countries, but policy cost effectiveness appeared comparable to Germany and the United Kingdom, in the range of A$300–400/t CO_2-e (figure 4). But Australia achieved relatively less abatement when measured as a proportion of road transport sector emissions. Germany has devoted considerable resources to biofuels, and proportionately was found to have achieved the highest amount of abatement.

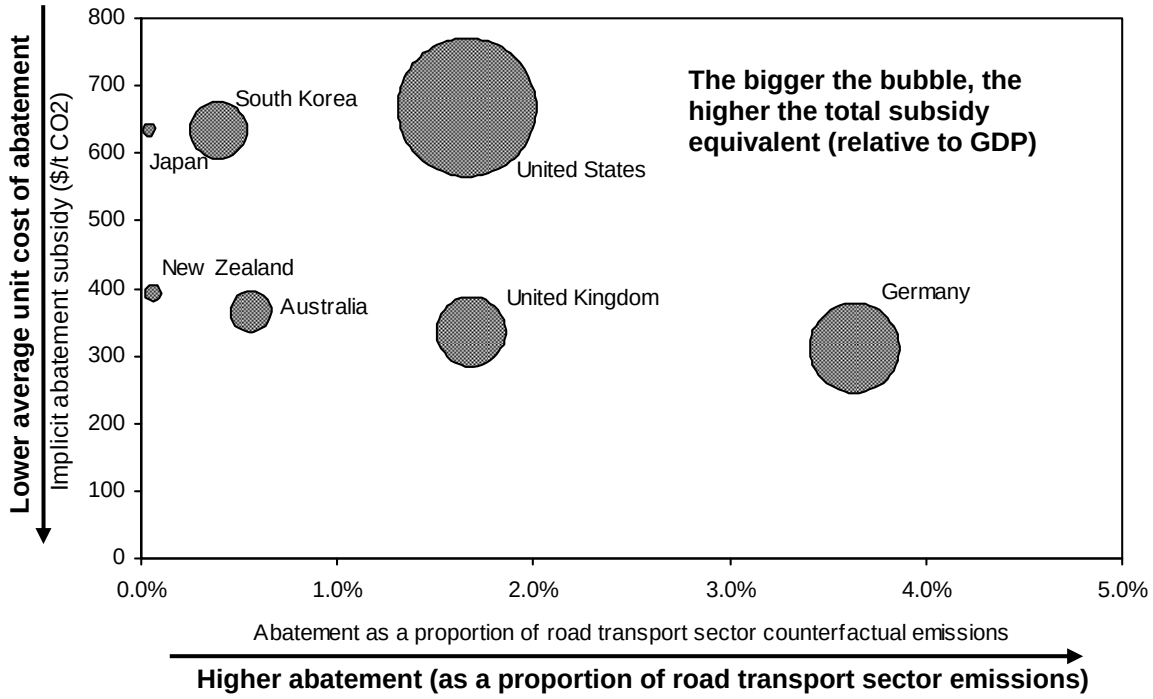
The United States stands out in this analysis, having by far the highest commitment of resources relative to GDP and poor cost effectiveness for only moderate proportionate abatement. This result appears to have been driven by the payment of assistance to domestic biofuel producers to induce local production at the expense of cheaper imports.

Cost effectiveness against a carbon price benchmark

The cost effectiveness of a country's policy measures can best be placed in perspective by making comparisons with the carbon tax (or emissions permit price) that would achieve the same amount of abatement when applied on an economy-wide basis. Economy-wide models for each country would be needed to estimate these prices. While a number of such models exist, developing and applying them consistently to all of the economies in sufficient detail to capture the impacts of particular policies would be an extensive and time-consuming task (and thus could not be attempted for this study).

Figure 4 **'Effort' and reward — how countries compare**

Road transport (biofuels) 'central' estimates, 2010



Nevertheless, to provide some indication of the cost effectiveness of actual policy measures, the Commission undertook some highly stylised modelling for Australia, using an 'off-the-shelf' version of the MMRF model.

- Based on conservative assumptions, the modelling suggested that the 12.5 Mt abatement achieved by existing policies for the electricity generation sector in 2010 (including demand-side abatement) could have been delivered instead by a carbon price (for the electricity sector only) in the order of \$9/t CO_2, or at a fraction of the existing cost.
- Alternatively, it was estimated that a carbon pricing mechanism applying to the electricity generation sector, and imposing the same costs as the policies in place in 2010, could have reduced emissions by more than double the abatement achieved.

The results highlight the potential gains from exploiting lower-cost opportunities for abatement over higher-cost ones. However, they do not indicate what carbon price would be required to achieve additional abatement in combination with existing schemes; nor can they be extrapolated to estimate the carbon price that would achieve agreed emissions levels.

1 Introduction

This study documents the policies used by Australia and other selected economies to reduce greenhouse gas emissions, and provides comparative estimates of their costs and associated abatement. The study was commissioned by the Australian Government to 'provide accurate and timely information on the extent of climate action in key economies and sectors' (terms of reference).

1.1 The Commission's task in brief

The terms of reference essentially ask the Commission to:

- examine and detail key emissions-reduction policies either in place or committed in Australia and other key economies, such as China, Germany, India, Japan, New Zealand, South Korea, the United Kingdom, and the United States
- estimate the effective carbon price per tonne of carbon-dioxide equivalent (CO_2-e) emissions faced by the electricity-generation sectors in these economies, and selected industries drawn from manufacturing and transport sectors in these and other countries, where relevant and data permitting
- report on the methodology, assumptions and data sources used, so as to inform further analysis in this area.

Estimating 'effective carbon prices' involves difficult conceptual and practical issues. The key conceptual challenge relates to how diverse policies that do not involve the explicit pricing of carbon emissions can be captured in a common price-related metric. Various carbon-price equivalents have been suggested, but none can replicate all impacts of an abatement subsidy scheme. The strongest conceptual basis for comparative purposes involves estimation of abatement costs associated with different policies, and this study has accordingly focused on these. Nevertheless, at a practical level, it has often been difficult to assemble robust data and some of the results are no more than indicative. These issues are covered in depth in chapters on methodology (chapter 3) and some specific sectors (chapters 4 and 5).

1.2 Background to the study

The Australian Government commissioned this study in order to 'help inform the Government's plan to introduce a carbon price in Australia' (Combet, Swan and Shorten 2010). That plan is being formulated with the assistance of the Multi-Party Climate Change Committee (MPCCC), which was established by the Australian Government to 'explore options for the implementation of a carbon price' and to 'help to build consensus on how Australia will tackle the challenge of climate change' (DCCEE 2010c). The MPCCC comprises senior members of the Government (including the Prime Minister) and the Australian Greens, as well as two independent Members of Parliament.

When the Government announced the formation of the MPCCC, it noted that the Committee would be informed by various individuals and agencies, including:

- three independent experts — Ms Patricia Faulkner, Mr Rod Sims and Professor Will Steffen — who would regularly advise the MPCCC on their areas of expertise[1]
- Professor Ross Garnaut, who would also act as an independent expert adviser to the MPCCC, provide an update of his 2008 Climate Change Review (box 1.1), and give advice on pricing carbon
- the Australian Academy of Science, Bureau of Meteorology, Climate Change Commission, CSIRO, and eminent scientists to provide up-to-date assessments of the relevant science
- an 'expert body' tasked with calculating the carbon-price equivalent of measures taken by other countries (DCCEE 2010d).

In November 2010, the Government assigned the latter task to the Productivity Commission. The Government noted that this study would help inform debate about:

- the extent to which Australia was taking action on climate change relative to the efforts of other countries (sometimes referred to as 'comparable effort')
- how the introduction of a carbon price would affect the international competitiveness of Australia's emissions-intensive trade-exposed industries (Combet 2010b, 2010c; Combet, Swan and Shorten 2010).

A proposed carbon-price mechanism was announced by the Government in February 2011. The proposal involves a fixed carbon price to commence on

[1] Mr Rod Sims stood down from his role as an expert advisor in May 2011 due to his nomination as Chairman of the Australian Competition and Consumer Commission.

1 July 2012, which after three to five years could transition to an emissions trading scheme. The starting level of the carbon price was to be the subject of future discussions in the MPCCC.

Box 1.1 **Update of Garnaut Climate Change Review**

In September 2008, the Garnaut Climate Change Review — led by Professor Ross Garnaut — reported to the Australian, State and Territory Governments on recommended medium to long-term policy options to address human-induced climate change. The recommendations were based on an assessment of the likely impacts of climate change on Australia in the absence of effective international efforts to cut emissions; and the climate and economic impacts on Australia of various potential international and Australian policy interventions.

In November 2010, Professor Garnaut was commissioned by the Australian Government to update elements of his 2008 review, where significant changes had occurred, or the sum of expert knowledge had increased, and these would have significant implications for the key findings and recommendations of the review.

A series of publicly-released papers was to be prepared between November 2010 and March 2011, and a final report presented to the Government by 31 May 2011.

Sources: Combet (2010a); Garnaut (2008).

Given the methodological and practical issues the Commission has encountered when seeking to estimate carbon prices, and some expectations about how this study's results might be used, considerable attention has been given throughout this report to explaining the basis for the results and how they should be interpreted.

This study has some similarities to a report prepared by Vivid Economics (2010) for the Climate Institute (2010). However, that exercise was largely confined to a subset of policies that supported 'low-carbon' electricity generation, such as wind and solar. In comparison to Vivid Economics' earlier work, the key extensions in this study include a broader coverage of policies and sectors, and the use of a more extensive set of data sources and expertise. The Commission's methodology also differs from that used by Vivid Economics in important respects (chapter 3).

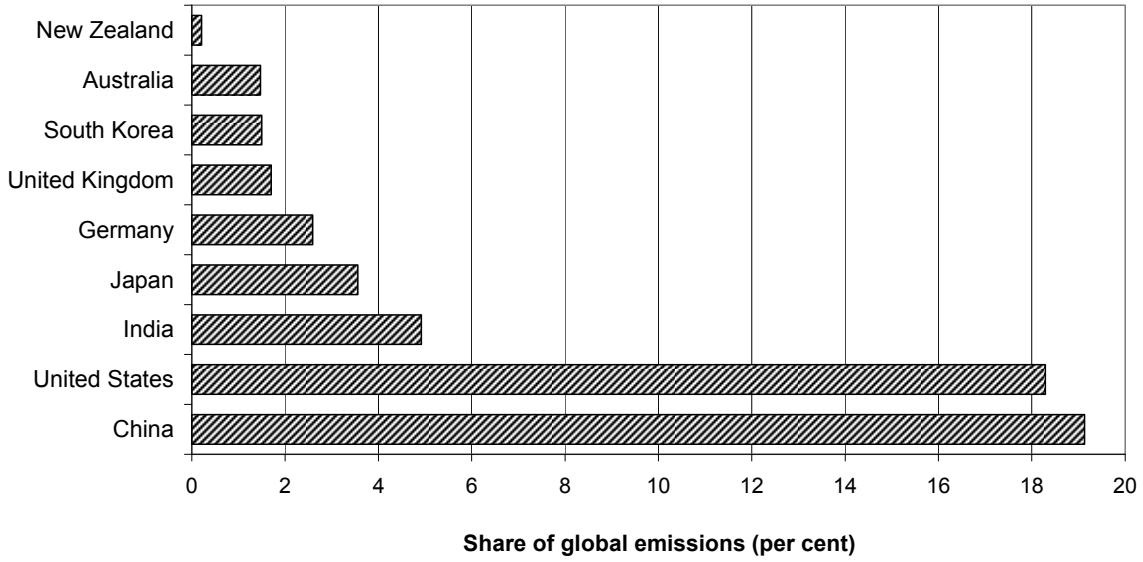
1.3 Scope of the study

A threshold consideration for the study has been what countries, sectors and policies to include, particularly for estimation purposes. Expectations that the study would contribute to debate about 'comparable effort' and international competitiveness

was factored into this consideration, along with other issues such as data availability.

As previously noted, the terms of reference mentioned eight countries in addition to Australia; namely, China, India, Japan, Germany, New Zealand, South Korea, the United Kingdom, and the United States. They include the world's largest emitters (figure 1.1) and Australia's most important trading partners. While a case could be made for including additional countries such as Canada — on the grounds that it has a similar economic structure to Australia — or other major trade competitors, this would not have been feasible within the timeframe for this study.

Figure 1.1 **Share of global greenhouse gas emissions by country[a]**
2005



a Excludes land-use change. Emissions are measured in terms of carbon-dioxide equivalents. Comprehensive emissions data that include all six Kyoto gases (CO_2, CH_4, N_2O, PFCs, HFCs, SF_6) for developed and developing countries are not currently available beyond 2005.

Source: WRI (2011).

With respect to sector and policy coverage, a distinction has to be made between the study's stocktake of policies and the quantitative analysis. For the stocktake, the Commission sought to document key emissions-reduction policies in each country regardless of the sector to which a policy applied. In contrast, a narrower coverage of sectors and policies was needed to make the quantitative analysis feasible, given the significant data requirements and time-intensive nature of that task.

The scope of the study was also influenced by the degree to which governments in the covered countries provided assistance to the Commission. This varied

considerably. However, only in the case of India, which chose not to participate, was the Commission unable to obtain adequate information to conduct analysis.

Sectors included in the quantitative analysis

The terms of reference required effective carbon prices to be estimated for the electricity-generation sector, and suggested that they also be estimated for selected industries drawn from the manufacturing and transport sectors, 'where relevant and data permitting'. The Commission interpreted the term 'relevant' as meaning closely connected to the Government's and MPCCC's consideration of an Australian carbon price. As noted above, this encompasses the issues of 'comparable effort' between countries, and international competitiveness.

The Commission considered that the study was more likely to provide information relevant to assessing comparable effort if it concentrated on sectors that were significant emitters and had been targeted extensively by abatement policies.[2] With respect to concerns about international competitiveness, the most relevant coverage would appear to be emissions-intensive trade-exposed industries.

The emissions processes associated with electricity generation and transport account for around half of Australia's emissions (figure 1.2). Manufacturing industries are associated with a range of emissions processes, and so the relative significance of their emissions can only be determined by disaggregating the data by economic sector.[3] In doing so, it is useful to distinguish between the direct emissions that manufacturers generate, and their indirect emissions from the use of electricity.

In 2009, direct emissions from Australian manufacturing amounted to around 67 Mt (table 1.1). That was equivalent to about 12 per cent of total Australian emissions in 2009 (DCCEE 2011c). In comparison, direct emissions from Australian electricity generation were around 207 Mt (DCCEE 2011d). However, almost one-third of the direct emissions from electricity generation were associated with electricity use in manufacturing. As a result, manufacturing's indirect emissions from electricity use (63 Mt) were nearly as large as its direct emissions (67 Mt).

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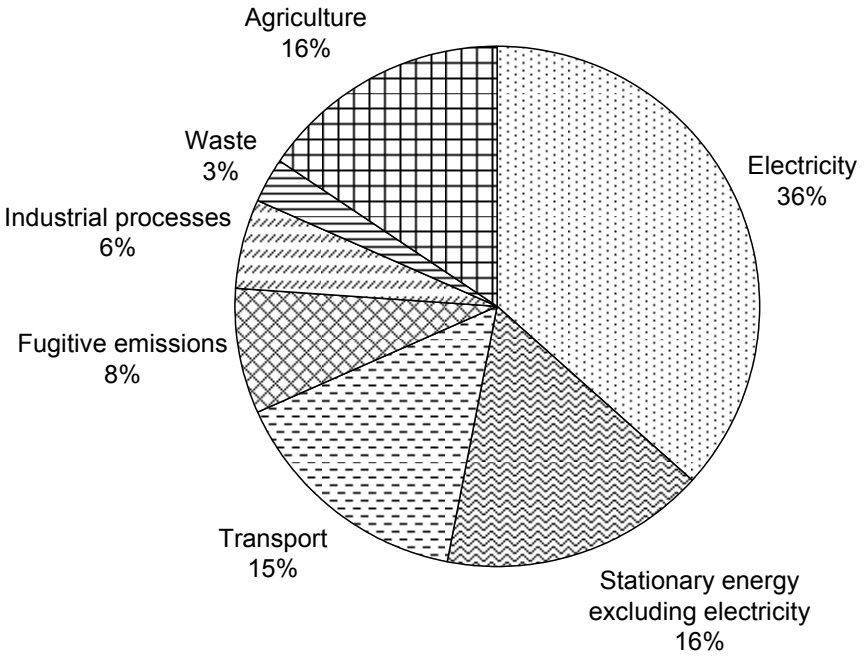
2 An important qualification here is that carbon prices can be a misleading indicator of comparable effort. As noted in chapter 3, inefficient policies could be given greater credit than those that achieve the same abatement at a lower cost. Moreover, a high carbon price does not necessarily indicate that a country experiences a greater proportionate impact on its economy or emissions.

3 For example, direct emissions from aluminium production are included in 'industrial processes', while fuel combusted for energy in the production process is included in 'stationary energy excluding electricity' (DCCEE 2010b).

Figure 1.2 **Australian greenhouse gas emissions by emissions process[a]**
2009-10



a Excludes land use, land-use change, and forestry. Emissions are measured in terms of carbon-dioxide equivalents.

Source: DCCEE (2010b).

The relative importance of indirect emissions will vary among specific industries within manufacturing, but data are not available from the National Greenhouse Accounts to assess this. Nevertheless, the data for manufacturing as a whole suggest that, by analysing policies that target electricity generation, the study would also cover a significant proportion of abatement policies relevant to manufacturing. This would particularly be the case for emissions-intensive trade-exposed industries that have a high reliance on electricity, such as aluminium production.

The Commission found that policies targeting direct emissions from manufacturing tended to have a narrower coverage of the sector than those for electricity generation, reflecting the manufacturing sector's greater heterogeneity. This raised the prospect of having to estimate carbon prices for a wide range of disparate policies across manufacturing industries, which collectively appear to be less significant (in terms of emissions covered or abatement achieved) than the key policies targeting electricity generation.

Heterogeneity is also a feature of the transport sector. For example, it would be difficult to attribute emissions abatement and costs associated with policies targeting international aviation and shipping to specific countries. For this reason,

and as a result of certain international agreements, emissions abatement in these sectors is being pursued through international, rather than domestic, policy-development processes. In contrast, land transport has a much stronger linkage to a specific country. Over 90 per cent of Australia's land-transport emissions come from road transport (DCCEE 2011c).

Table 1.1 **Greenhouse gas emissions associated with Australian manufacturing**
2009

Economic sector[a]	*Emissions*
	Mt CO_2-e
Direct emissions[b]	
Food, beverages, tobacco	3.85
Textile, clothing, footwear and leather	0.39
Wood, paper and printing	2.35
Petroleum, coal and chemical	17.34
Non-metallic mineral products	11.47
Metal products	30.65
Machinery and equipment	0.49
Other manufacturing	0.02
Total manufacturing	66.56
Indirect emissions from purchased electricity[c]	**62.97**

[a] Sector definitions are those used in the Australian and New Zealand Standard Industrial Classification. [b] Direct emissions are produced from sources within the boundary of an organisation and as a result of that organisation's activities. [c] Purchased electricity is defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity.

Sources: DCCEE (2010a, 2011c, 2011d).

In light of the above, and given the time frame of the study, the Commission therefore decided only to analyse policies directly targeting electricity generation and road-transport fuels (those used in road freight and private vehicle use).

Policy coverage

As noted above, this study's policy stocktake covered a wider range of policies than the quantitative analysis. However, even for the stocktake, the Commission considered it necessary, in order to make the task feasible, to apply a 'filter' to screen out less significant measures. Thus, for example, the policies of local governments tended to be excluded, on the grounds that their impact on national abatement was limited. On the other hand, it was considered important to include policies that, while not having an explicit objective to reduce emissions, did appear

to have a material impact on emissions. Further detail on the approach used to select policies for the policy stocktake is provided in chapter 2.

An overarching issue for both the policy stocktake and quantitative analysis was the inclusion, as requested in the terms of reference, of 'committed' policies that are not yet in place. In broad terms, the Commission considered a policy to be committed if it had a high probability of being implemented. In practice, this required a degree of judgement based on a range of information, including whether a policy had reached an early stage of enactment, such as being tabled in the country's legislature, where relevant. A further criterion was that the necessary details required to describe and analyse the policy had been announced. It should also be noted that governments in all of the relevant countries were given an opportunity to provide feedback on the policies documented and analysed in the study.

A range of criteria were used to select the subset of policies in the stocktake for which abatement costs were estimated. The criteria included that the selected policies penalised emissions or subsidised abatement, and accounted for a sizeable share of emissions reductions or abatement costs in the relevant sector. Some types of policies — such as energy-efficiency initiatives, R&D subsidies, education campaigns and voluntary schemes — were excluded on the grounds that any associated emissions abatement was highly uncertain, and may not occur until far into the future.

1.4 Conduct of the study

The terms of reference for this study were received from the Assistant Treasurer on 15 November 2010, with the Commission being given about six months to complete its report to the Government.

Given the timeframe for the study, and that it was largely a technical exercise, the Commission proceeded somewhat differently from most other studies and inquiries it undertakes. For example, it did not call for public submissions. Nor was it feasible to publish a formal draft report.

Nonetheless, the Commission endeavoured to remain as accountable and transparent as possible, and to draw on a sufficiently wide range of expertise. In summary, this involved:

- keeping interested parties informed about progress of the study, including by publicly releasing a background paper on study processes and a working paper on the proposed methodology for the quantitative analysis

- consulting a wide range of interested parties in Australia and the other study countries, including through face-to-face meetings, a roundtable on methodology, briefings to industry forums, and overseas phone calls and correspondence
- obtaining information from expert bodies in the study countries, including the Energy Research Institute of the Chinese National Development and Reform Commission, and energy agencies in Japan and South Korea
- hiring contractors in Australia and other countries to assist with the acquisition of information on emissions-reduction policies and the data required to calculate carbon prices
- providing draft results to governments and other relevant experts in the study countries for comment
- making as much of the data and contractor reports used in the study as publicly available as possible.

Further details are outlined in box 1.2. The parties who assisted the study — including those that participated in meetings, provided comments on draft results, and acted as contractors — are listed in appendix A.

The Commission is grateful to all those who participated in meetings and roundtables, and provided data and other assistance. The Commission also thanks staff in Australia's overseas embassies, who facilitated contact with governments and experts in the study countries. The assistance provided by governments in China, Germany, Japan, New Zealand, South Korea, the United Kingdom and the United States, as well as in Australia (including the states and territories), is also appreciated.

The remainder of this report is structured as follows. The next chapter summarises the stocktake of emissions-reduction policies for each country. Chapter 3 outlines the methodology used for the quantitative analysis. Chapters 4 and 5 summarise the resulting estimates for the electricity-generation and road-transport sectors respectively. Finally, chapter 6 wraps up the report by drawing together the key messages from the policy stocktake and quantitative analysis.

The report is supported by a number of appendices. Three of the appendices are provided in printed form at the end of this document. These list the parties that participated in the study (appendix A), summarise the emissions-reduction policies analysed in chapters 4 and 5 (appendix B), and describe energy-efficiency policies in the study countries (appendix C).

Box 1.2 **Consultations and expert input**

As requested in the terms of reference, the Commission consulted with the business sector, government agencies and other interested parties, and utilised research expertise in the economies that were examined. The relevant parties are listed in appendix A. In summary:

- Shortly after receiving the terms of reference, the study was publicised on the Commission's website, a background paper was released, and interested parties were invited to register their interest.
- The Commission held meetings with a cross-section of interested parties in Australia, including government agencies, representatives from the electricity-generation sector, and Professor Ross Garnaut. Aspects of the study were also discussed, by telephone and in writing, with parties in other countries who had relevant expertise.
- The Commission initiated consultations with Australia's Department of Foreign Affairs and Trade (DFAT) at an early stage in the study. DFAT facilitated contact with parties in other countries, and provided comments on early drafts of the policy stocktakes for individual countries.
- The Chairman of the Productivity Commission wrote to the heads of relevant government agencies in all of the study countries seeking their assistance.
- A roundtable was held with an expert group in Melbourne on 1 December 2010 to explain the study process and obtain input on what data and methodology to use. The participants came from government, industry, private consulting firms, and universities.
- The Chairman of the Productivity Commission made presentations at three industry forums in March 2011 to brief interested parties on progress of the study and elicit their feedback.
- A paper outlining the methodology to be used for the quantitative analysis was publicly released in March 2011 (PC 2011). Drafting of the paper had benefited from written comments by individuals who had attended the December roundtable.
- Contractors in Australia and other countries were hired to assist with the acquisition of information on emissions-reduction policies in the study countries, and the data required for a quantitative analysis of policies in the electricity and transport sectors. A single consortium of contractors covered all countries apart from Australia. Other contractors with specific country or industry expertise were hired to provide supplementary information for a subset of the study countries.
- Excerpts of this report, and the associated policy stocktakes and quantitative results, were circulated in draft form to relevant experts in Australia and overseas for comment. This included national governments in each country covered by the study.

The remaining appendices are available on the Commission's website. They provide the detailed information and analysis on which this document is based. In particular, there are detailed policy stocktakes for each study country, and in-depth descriptions of the quantitative analysis for the electricity-generation and road-transport sectors.

2 Emissions-reduction policies

Key points

- There is a large number and diverse range of emissions-reduction policies in place, and in the process of being implemented, in nearly all of the nine countries studied — the Commission has identified more than 1000 policies in total.
- Some countries use cross-sectoral policies.
  - Germany, the United Kingdom and New Zealand operate multi-sector — but not yet economy-wide — emissions trading schemes (ETSs). (ETSs are under consideration or proposed in Australia, China, Japan, South Korea, and the United States.)
  - The United States is in the process of setting economy-wide emissions standards for all large emitters of greenhouse gases.
- Most countries have adopted sector-specific policies, primarily targeting electricity generation and road transport and, to a much lesser extent, agriculture and forestry. Few policies specifically target other sectors (such as resources or manufacturing).
- In the electricity generation sectors of the countries studied:
  - renewable energy targets (using certificate schemes) and feed-in tariffs (often supported by capital subsidies) are the primary emissions-reduction policies
  - subsidies and preferential loans to support the construction of renewable generation capacity are common
  - technology standards (regulating generation technology and emissions levels) are also used
  - electricity-specific ETSs are in use in the United States (across ten states) and Australia (in New South Wales). The cross-sectoral EU and NZ ETSs also apply.
- In the transport sectors of the countries studied:
  - policies predominantly target fuels and vehicles. Fuel taxes, government assistance to biofuels (such as fuel content mandates and excise exemptions), and vehicle fuel efficiency standards are the primary emissions-reduction policies
  - tax exemptions and subsidies for lower-emissions vehicles are common
  - policies such as investment in public transport and freight infrastructure, that may less directly reduce emissions, are widely used.
- A wide range of energy efficiency policies targeting households and businesses are in place in all the countries studied.

This chapter summarises the emissions-reduction policies of the nine countries covered by this study — Australia, China, Germany, India, Japan, New Zealand, South Korea, the United Kingdom, and the United States. Specific details of the policies analysed in chapters four and five are in appendix B, and a full stocktake of policies can be found on the Commission's website (appendix P).

2.1 Approach

The Commission used three main criteria in determining whether to include policies in its stocktake. Generally, policies were included if they:

- are in place or committed — where 'committed' means the policy not only has a high probability of being implemented, but specific details have also been released (for example, the policy is in the process of enactment)
- have the explicit intent, or the effect, of reducing emissions (for example, fuel excises are often considered to be road-user charges or general taxation but they also have the effect of reducing emissions)
- operate at the national or state/provincial level (policies at the local government level were generally not included because they are not likely to be material to cross-country comparisons).

The Commission used two further criteria to identify the smaller number of policies analysed in chapter 4 (electricity generation) and chapter 5 (road transport). Generally, policies were analysed if they:

- penalise emissions or give an incentive for abatement (which covers explicit or implicit taxes and subsidies, and regulations, but not voluntary codes)
- have a material impact on a country's emissions in a sector and/or impose significant total costs.

The stocktake was compiled by the Commission through a combination of its own research, utilisation of existing stocktakes of emissions-reduction policies[1], consultation with government agencies in each of the study countries, and assistance from specialist consultants. Governments in each of the study countries were given the opportunity to comment on a listing of their country's policies, while in draft form.

[1] Datasets include those published by the International Energy Agency, the United Nations Framework Convention on Climate Change and the Department of Climate Change and Energy Efficiency (Australia).

The Commission's stocktake identified over 1000 policies across the nine countries, with large numbers in nearly all of the countries studied (table 2.1).

Table 2.1 **Number of policies in the stocktakes, by country**

	Australia	*China*	*Germany*	*India*	*Japan*	*NZ*	*South Korea*	*UK*	*US*	*Total*
Number	237	82	131	68	67	31	69	104	307	1096

The stocktakes include the key policies analysed in chapters 4 and 5, as well as other policies identified in each country. However, it is unlikely to be exhaustive for all countries. For example, given time and resource constraints, research for the United States necessarily focused on federal government policies, similar policies used in multiple states, schemes in which multiple states participated, and other state government policies in the five states with the largest greenhouse gas emissions.

Emissions-reduction policies were classified into specific categories using a taxonomy based loosely on one developed by the International Energy Agency (IEA 2011b). The Commission's taxonomy has six broad categories and 33 policy types (table 2.2).

Table 2.2 **Taxonomy of emissions-reduction policies**

Explicit carbon prices	***Regulatory instruments***
Emissions trading scheme — cap-and-trade	Renewable energy target
Emissions trading scheme — baseline and credit	Renewable energy certificate scheme
Emissions trading scheme — voluntary	Electricity supply or pricing regulation
Carbon tax	Technology standard
Subsidies and (other) taxes	Fuel content mandate
Capital subsidy	Energy efficiency regulation
Feed-in tariff	Mandatory assessment, audit or investment
Tax rebate or credit	Synthetic greenhouse gas regulation
Tax exemption	Urban or transport planning regulation
Preferential, low-interest or guaranteed loan	Other regulation
Other subsidy or grant	***Support for research and development (R&D)***
Fuel or resource tax	R&D — general and demonstration
Other tax	R&D — deployment and diffusion
Direct government expenditure	***Other***
Government procurement — general	Information provision or benchmarking
Government procurement — carbon offsets	Labelling scheme
Government investment — infrastructure	Advertising or educational scheme
Government investment — environment	Broad target or intergovernmental framework
	Voluntary agreement

For the purposes of presentation in this chapter, most policies were also grouped by sector. In particular, they were divided into those that have cross-sectoral coverage and those that are specific to electricity generation, transport, forestry and agriculture. This was done so that the documentation of key policies here aligns with the sector-specific analysis in chapters 4 and 5.

The one exception to this sectoral approach was energy efficiency policies. The main types of energy efficiency policies are summarised in the last section of this chapter, with more detailed discussion on select policies in appendix C.

A number of industries (such as resource extraction, processing and manufacturing) are not presented separately by sector in this chapter. Generally, this is because there are few emissions-reduction policies that are specific to these industries in the countries studied. Their emissions are covered (to varying degrees) through:

- cross-sectoral policies (such as emissions trading schemes (ETSs), carbon taxes or emissions standards that apply to sources of emissions across an economy)
- energy efficiency policies (that target large users of energy, including electricity oil, gas, coal and biomass).

Emissions in these industries are also indirectly covered to the extent that they use an input covered by other policies (such as electricity or transport policies). For example, while there are few policies specifically targeting manufacturing emissions in Australia, approximately half of the sector's total emissions are from electricity that is already subject to a range of emissions-reduction policies (chapter 1).

Details on individual policies analysed in chapters 4 and 5 are provided in appendix B, and a full stocktake of policies can be found on the Commission's website (appendix P).

Copenhagen Accord commitments

In 2010, each study country made an international commitment to reduce or limit the growth in their emissions by a 2020 deadline as part of the Copenhagen Accord (table 2.3). However, the commitments are expressed in ways that are not directly comparable. The 2020 targets for Australia, Germany, Japan, New Zealand, South Korea, the United Kingdom and the United States are expressed as a percentage reduction in emissions relative to the level of emissions in a base year. Base years vary from 1990 (for Germany, Japan, New Zealand and the United Kingdom), to 2000 (for Australia), to 2005 (for the United States). Commitments for China and

India are expressed as a reduction in emissions per unit of GDP (emissions intensity) against the base year 2005.

McKibbin, Morris and Wilcoxen (2010) attempted to convert the various countries' commitments into common terms — a percentage change in emissions relative to a standard base year.[2] They used the G-Cubed model of the global economy to estimate emissions under a 'no policy action' scenario (business as usual), and emissions resulting from a stylised implementation of the Copenhagen targets. The authors used these two scenarios to reformulate the original Copenhagen targets into equivalent targets with common base years of 1990, 2000, 2005 and 2020.

Table 2.3 **Emissions-limitation commitments under the Copenhagen Accord, by country**

Country	*Commitment to limit emissions by 2020, relative to various base years*
Australia	5 per cent to 25 per cent below 2000 level Moving above 5 per cent is conditional on a global, comprehensive agreement.
China	40 per cent to 45 per cent cut to 2005 emissions intensity level[a] Increase the proportion of non-fossil fuels used in primary energy consumption to 15 per cent, and increase forest coverage by 40 million hectares and forest stock volume by 1.3 billion cubic metres relative to 2005.
Germany	20 per cent to 30 per cent below 1990 level Moving above 20 per cent is conditional on a global, comprehensive agreement for the period beyond 2012.
India	20 per cent to 25 per cent cut to 2005 emissions intensity level[a]
Japan	25 per cent below 1990 level Conditional on all major economies joining a 'fair and effective international framework with ambitious targets'.
New Zealand	10 per cent to 20 per cent below 1990 level, conditional on a global, comprehensive agreement.
South Korea	30 per cent below business as usual level
United Kingdom	20 per cent to 30 per cent below 1990 level Moving above 20 per cent is conditional on a global, comprehensive agreement for the period beyond 2012.
United States	17 per cent below 2005 level[b]

a An 'endeavour' to reduce emissions intensity. **b** 'In the range of' 17 per cent.

Source: DCCEE (2010c).

McKibbin, Morris and Wilcoxen (2010) found that varying the base year used to express a commitment can significantly affect its apparent stringency. They also note that expressing emissions-reduction targets relative to a given base year gives little useful information about the actual size of the reduction required by 2020 compared to a business as usual scenario. For example, Australia's 2020

2 Where commitments are conditional or given as a range, the lower-bound levels were used.

Copenhagen commitment to an unconditional emissions reduction of 5 per cent on 2000 levels is estimated to be equivalent to a 30 per cent increase in emissions on 1990 levels, an 18 per cent reduction relative to 2005 levels, and a 35 per cent reduction against business as usual emissions levels in 2020.

When expressing Copenhagen commitments in terms of reductions against business as usual projections by 2020, McKibbin, Morris and Wilcoxen (2010) estimated that Japan has committed to the largest reduction (48 per cent), Australia's commitment is in line with that of Europe (36 per cent) and the United States (33 per cent), while China's commitment is smaller (22 per cent). India's commitment is estimated to result in an increase in emissions of 0.4 per cent by 2020, compared with business as usual.[3]

2.2 Cross-sectoral policy measures

Most of the policy measures in the countries studied apply to a particular sector. But there are some cross-sectoral policies that target emissions more broadly. The most widely applied cross-sectoral policies are emissions trading schemes. Carbon taxes are not currently used, but are under consideration in Japan and South Korea. The United States is in the process of introducing greenhouse gas emissions standards for all large stationary emitters.

Emissions trading schemes

ETSs are the only policy type that involve an explicit market price on emissions. The most common form of ETS is a cap-and-trade scheme that sets a limit on the amount of emissions, with permits issued that allow holders to emit greenhouse gases up to a quantitative cap. Permits can be traded, thus establishing a market 'price' for emissions.

Among the countries studied, the United Kingdom and Germany participate in the European Union's cap-and-trade ETS. The scheme applies to multiple sectors covering around 40 per cent of EU emissions. New Zealand operates a national ETS that is currently in a transition phase — there is no binding cap on total emissions and the government has effectively capped the price of emissions certificates. The New Zealand ETS covers a range of sectors accounting for around 45 per cent of the country's emissions. A cap-and-trade ETS is planned for a group of western

[3] McKibbin, Morris and Wilcoxen (2010) did not report estimates for South Korea and New Zealand.

states in the USA, although it is likely that the scheme will only cover California by 2012 (box 2.1).

The Australian Government has announced that it is planning to introduce an ETS in July 2012, with a fixed price on emissions permits for the early years of the scheme (chapter 1). Japan and South Korea have also proposed the introduction of an ETS, although implementation has been delayed (Reuters 2010). China is considering trialling a pilot ETS in some of its provinces (Reuters 2011). Japan, South Korea and China currently operate voluntary ETSs of limited scope. ETSs that apply exclusively to electricity generation are discussed in section 2.3.

Carbon taxes

A carbon tax is an alternative mechanism for effectively putting an explicit price on emissions. Carbon taxes have generally not been used to date in the countries studied. However, some governments have taxed the use of fossil fuels. For example, the UK Climate Change Levy (introduced in 2001) is a tax on energy used by business and the public sector (including electricity, gas and coal). The tax rate depends on the energy content of the fuel rather than emissions. The Japanese Government has announced that the Petroleum and Coal tax — a pre-existing (revenue) tax on crude oil and petroleum products — will be increased in stages over the next four years based on the 'emissions content' of fossil fuel inputs. South Korea is considering introducing a carbon tax from 2012. In its early years, Australia's fixed price ETS would be equivalent to a carbon tax.

US greenhouse gas emissions standards

An 'emissions standard' places restrictions on the type and quantity of emissions that can be released into the atmosphere from a specified source. The US Environmental Protection Agency (USEPA) has the power to regulate greenhouse gas emissions under the *US Clean Air Act 1963*. In January 2011, the USEPA progressively began requiring large stationary greenhouse gas emitters to hold a permit to continue emitting. Initially, permits are being required only for the largest emitters (covering fossil fuel electricity generators and petroleum refineries). Eventually, they will be required for any type of stationary installation emitting more than 50 000 tonnes of greenhouse gases per year (covering approximately 70 per cent of US emissions).

Box 2.1 **Cross-sectoral emissions trading schemes**

European Union

The European Union Emissions Trading Scheme (ETS) commenced in 2005 and operates in 30 countries (including Germany and the United Kingdom). It covers CO_2 emissions from power stations, combustion plants, oil refineries, iron and steel works, and factories making cement, glass, lime, bricks, ceramics, pulp, paper and board. Transport fuels, agriculture and forestry are not covered. Aviation fuels will join the scheme in 2012 with the petrochemicals, ammonia and aluminium industries and additional greenhouse gases to be covered in 2013. Covered emitters are obliged to surrender one European Union Allowance (EUA) for each tonne of CO_2 emitted. The total number of EUAs issued is capped at a level consistent with the target for EU-wide emissions, and permits are traded. Offset credits obtained under the Kyoto Protocol Clean Development Mechanism can be used to meet obligations under the European Union ETS. From 2013, the emissions cap will decline annually to achieve a 21 per cent reduction relative to 2005 levels by 2020. In May 2011, the spot price was around €16–17 (A$22–23).

New Zealand

The New Zealand ETS commenced in 2008. It covers forestry, electricity generation, transport fuels (including domestic aviation and coastal shipping) and industrial processes. Waste and synthetic gases are scheduled to be covered from 2013, and agriculture from 2015. Emissions include CO_2 from liquid fossil fuels, and CO_2 and methane from electricity. By 2015, all sectors of the economy will be covered. Covered emitters must surrender New Zealand Units (NZUs) to cover emissions. Currently, the number of NZUs that can be issued is not capped. In the transition phase (July 2010 to December 2012), firms with ETS obligations are only required to surrender one permit for every two tonnes of emissions. Emitters may pay NZ$25 (A$20) instead of surrendering a NZU, effectively capping the per-tonne price at NZ$12.50 (A$10). Offset credits obtained under the Kyoto Protocol Clean Development Mechanism can be used to meet obligations under the New Zealand ETS. From 2013 onwards, one permit will be required for each tonne of CO_2-e. Early 2011 spot prices for NZUs have ranged from NZ$19–21 (around A$14–16).

United States

The Western Climate Initiative was intended to cover seven US states (California, New Mexico, Washington, Oregon, Montana, Utah and Arizona) and four Canadian provinces (British Columbia, Ontario, Québec and Manitoba). The initiative aims to reduce emissions to 15 per cent below 2005 levels by 2020. Currently, it appears that only California is fully committed to implementing an ETS by 2012. The Western Climate Initiative has recommended that the 2012 cap be the same as projected emissions for that year. Therefore, it is likely that the permit price and abatement will be close to zero in 2012.

Sources: Appendixes B, F, H, J, K.

The USEPA is in the process of establishing the first industry-specific greenhouse gas emissions standards that will apply to permit holders. Draft emissions standards for electricity generation are scheduled for release in July 2011, and for petroleum refineries in December 2011. The mechanisms that will be used to meet the new standards are still unclear at this point. In the case of electricity generation, the EPA has indicated the types of abatement technologies that may be used. These include fuel switching (from coal to gas), carbon capture and storage (CCS), and improvements in generation efficiency (USEPA 2011a; 2011b). Technology standards that apply specifically to electricity generation and transport are discussed in sections 2.3 and 2.4 respectively.

2.3 Policy measures specific to electricity generation

Renewable energy targets (using certificate schemes) and feed-in tariffs (supported by capital subsidies and preferential loans for renewable generation) are the most widely applied policies targeting electricity generation in the countries studied. Technology standards and ETSs have been adopted to varying degrees. Fossil fuel taxes, differential electricity taxes, and direct tax incentives are used to a lesser extent (table 2.4).

Renewable energy targets

A renewable energy target — a type of technology standard — requires that a quantity or proportion of electricity be generated using specified renewable technologies over a given period of time. In some countries targets are aspirational. Targets can be met through renewable energy certificate schemes or various other policy instruments (such as feed-in tariffs).

Table 2.4 **Emissions-reduction policies specific to electricity generation, by country**

The jurisdictional coverage of a policy may be national (N), sub-national (S) or European Union (EU).

	Australia	*China*	*Germany*	*India*	*Japan*	*NZ*	*South Korea*	*UK*	*US*
Feed-in tariffs	S[a]	N,S	N	N,S	N		N	N	S
Renewable energy certificate schemes	N			S[b]	N		N[c]	N	S[d]
Other technology standards	S[e]	N						N	N,S[f]
Capital subsidies	N,S	N,S	N,S	N,S	N,S	N	N	N,S[g]	N,S
Preferential loans		N	N,S	N			N	N	N
Emissions trading schemes	S[h]	S[i]	EU[j]		N[k]	N[j]	N[l]	EU[j]	S[m]
Fossil fuel taxes				N	N				
Differential electricity taxes								N	
Tax incentives	S	N		N			N	N	N

[a] Each state (apart from Tasmania) operates its own policy. [b] A certificate trading scheme is under development. [c] From 2012. [d] Mandatory in 36 states; most of these states use certificate schemes. [e] Queensland Gas Scheme. [f] From January 2011, the US Environmental Protection Agency began the regulatory process for setting national emissions standards for all stationary installations that emit more than 50 000 tonnes per year. At least 6 states have their own current emissions standards. [g] In Scotland, Wales and England. [h] NSW and ACT Greenhouse Gas Reduction scheme (baseline and credit). [i] Several Chinese cities have implemented voluntary emissions trading schemes (including Beijing, Tianjin and Shanghai). [j] Cross-sectoral ETS that also applies to electricity generation. [k] Japan operates a small voluntary ETS. It appears that introduction of a national ETS has been delayed. [l] South Korea operates a small voluntary baseline and credit ETS. A national ETS is scheduled for 2015 although it appears that this has been delayed. [m] Ten states participate in the Regional Greenhouse Gas Initiative. The Western Climate Initiative is a framework to establish a cross-sectoral ETS, and intends to cover seven western US states and four Canadian provinces. Only California has committed to implementation by 2012.

Sources: Appendixes B, D–K.

Renewable energy certificate schemes are the most common instruments for implementing mandatory renewable energy targets among those countries studied. Under such schemes, tradable certificates are issued to renewable electricity generators for the units of electricity they produce. An obligation is placed on generators or electricity retailers to surrender these certificates to a regulator to meet the renewable energy target. Renewable generators receive the market price for the electricity they produce, and earn an additional subsidy by selling the certificate to a retailer or generator with obligations under the scheme. The rules governing how renewable electricity is certified vary between schemes, altering which renewable generation technologies are eligible for a subsidy, as well as the level of subsidy received per megawatt hour of electricity.[4]

Mandatory renewable energy targets of varying magnitude and using different instruments have been adopted in Australia, the United Kingdom and Germany (under European Union mandates), Japan, South Korea, and in a majority of US and Indian states. China has adopted an aspirational renewable energy target with sub-targets for different renewable generation technologies. New Zealand has an aspirational target (table 2.5).

Other technology standards

Diverse other technology standards are applied in the electricity sectors in the United States, the United Kingdom, China and Queensland. Generally, technology standards place requirements or restrictions on the construction or operation of generation technologies.

In the United States, a number of states place limits on the emissions intensity of new electricity generators. In the case of California, the emissions standard effectively prohibits new coal-fired power stations without CCS. In the United Kingdom, any new coal-fired power station with a capacity of over 300 megawatts (MW) is required to be ‘carbon capture ready’. Cross-sectoral emissions standards being implemented by the USEPA are discussed in section 2.2.

China’s Large Substitute for Small policy is a unique technology standard that requires the decommissioning of small, inefficient thermal power plants to allow the construction of larger, more economically efficient and less emission-intensive

4 Rules can govern: tethering — the type of generation technology eligible for certification; banding — the number of certificates created per megawatt hour of electricity; or carve outs — a mandate that a percentage of the renewable energy target must come from a designated technology.

electricity generation. Up to 2011, the policy focused on closing small plants (below 50 MW capacity), larger older plants (less than 100 MW and in operation for over 20 years), and plants of less than 200 MW that have reached the end of their design life. Between 2011 and 2020, more plants between 100 and 200 MW will be closed.

Table 2.5 **Renewable energy targets, by country**

Country	*Target*	*Instrument for meeting the target*
Australia[a] (National)	20% by 2020 Mandate	A tradable certificate scheme (the Large-scale Renewable Energy Target) covering large-scale renewable energy projects (such as wind and solar farms, and hydroelectricity schemes).
China (National)	15% by 2020 Aspirational	Various instruments including capital subsidies and feed-in tariffs for wind, biomass, solar and hydroelectricity. Individual targets are set for each source of generation.
Germany (National)	20% by 2020 EU Mandate	Feed-in tariffs.
India (At least 21 states)	From less than 1% to 14% by 2010-11 to 2015-16 Mandate	Renewable energy certificate trading is under development. Eligible technologies differ across states. Separate targets are set for solar and non-solar generation.
Japan (National)	Around 1% Periodic mandate	The government imposes a periodic obligation on electricity retailers to use a certain amount of renewable electricity. Eligible technologies include solar photovoltaic, wind, biomass, small hydroelectricity and geothermal.
New Zealand (National)	90% by 2025 Aspirational	To be implemented by removing 'unnecessary regulatory barriers' faced by renewable energy generation.
South Korea (National)	10% by 2020 Mandate	From 2012 companies with power generation facilities of more than 500 MW (currently 13) will be required to purchase renewable energy up to the target.
United Kingdom (National)	20% by 2020 EU Mandate	Tradable certificate scheme — different technologies receive different levels of support depending on their cost.
United States[b] (At least 41 States)	Varies by state Mandate and aspirational	Most states have renewable tradable certificate schemes. Some states use feed-in tariffs. Eligible technologies differ across states.

a Australia also operates the Small-scale Renewable Energy Scheme (SRES). This rewards owners of small-scale renewable generation such as heat pumps and solar water heaters, which receive Small-scale Technology Certificates. Electricity retailers are required to purchase a number of certificates each year. **b** Thirty-six states have mandated targets and five states have aspirational targets.

Sources: Appendixes B, D-K.

In Australia, the Queensland Government operates the Queensland Gas Scheme. The scheme requires electricity retailers to source a minimum percentage of their electricity from eligible gas-fired generation. The mandatory target increased from

13 per cent in 2008 to 15 per cent in 2010. By 2020, the target will rise to 18 per cent.

Feed-in tariffs

Feed-in tariffs pay a guaranteed tariff for electricity produced with prescribed technologies (generally renewable sources such as solar photovoltaic (PV) and wind generation). FITs are available for larger-scale generation (such as wind farms, biomass and biogas) and smaller-scale generation (such as domestic solar PV). Tariffs can be calculated on a net or gross basis. A net approach pays a tariff for surplus energy that is exported to the grid and not consumed on-site. A gross approach pays a tariff on all electricity produced. These tariffs are often higher than those paid by general consumers.

Feed-in tariffs apply at a national level in Germany, Japan, South Korea, and the United Kingdom, and at a state level in Australia. China and India operate national and sub-national schemes (figure 2.1). FITs also exist in some US states where they operate mainly as commercial arrangements between utilities and small-scale generators that the utilities use to meet their renewable energy target obligations. New Zealand does not use FITs.

The types of renewable technology eligible for FITs vary by country. South Korea and Germany offer FITs for hydroelectricity, biomass, biogas, wind and solar PV, while Australia and Japan offer FITs only for solar PV. FIT rates also vary between generation technologies. The level of FITs is highest for solar PV and lower for more established technologies such as wind, hydroelectricity and biomass. Average FITs are above average annual wholesale electricity prices in each study country, except for non-solar PV generation in South Korea.[5]

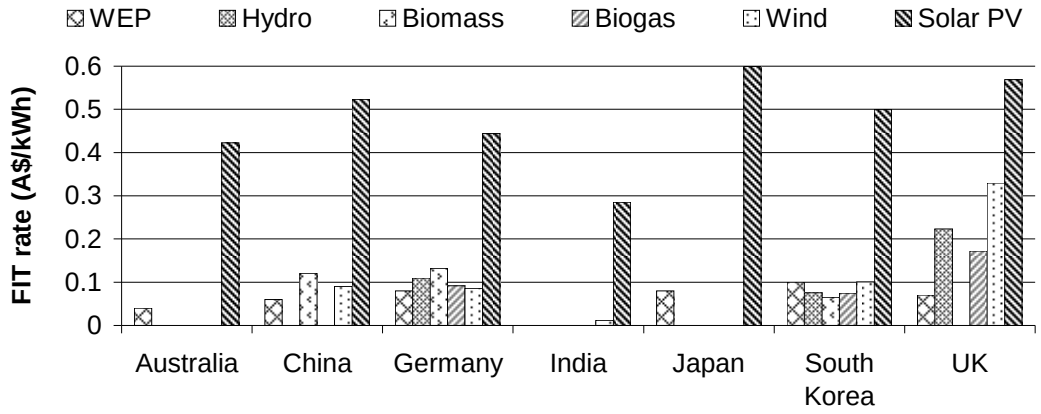
Capital subsidies

Capital subsidies are direct financial transfers from governments to households or firms investing in low-emissions electricity generation (such as solar PV cells or wind farms). Capital subsidies can have multiple objectives in addition to greenhouse gas reduction, such as addressing barriers to the adoption of energy efficiency measures and providing industry assistance. Capital subsidies are

5 South Korean average FITs for hydroelectricity, biomass and biogas are below the average South Korean wholesale electricity price. Average Korean FITs were calculated using fixed tariffs that appear to be below the average wholesale electricity price and a variable tariff often set above the wholesale electricity price.

typically offered by all levels of government in the countries studied. Subsidies are provided for widely varying purposes, from assisting in the provision of large-scale generation capacity to helping individual households and small businesses install small-scale generation. In many cases, subsidies are provided in addition to other financial incentives for renewable generation, such as feed-in tariffs and renewable energy certificates.

Figure 2.1 **Average feed-in tariffs for different technologies, by country[a]**
A$ (2010)



a Where multiple FITs exist for a given generation technology, unweighted averages have been calculated. Average FITs were not adjusted for net and gross differences and have been converted to 2010 Australian dollars. The wholesale electricity price (WEP) is an estimate of the 2010 average annual price per kilowatt hour paid to non-renewable generators. The Australian WEP is the unweighted average price for each National Electricity Market state. The Chinese WEP is for November 2010. The Indian WEP was not available. The South Korean WEP is for the year to 31 March 2010. South Korean average FITs were calculated using a mixture of fixed tariffs that appear to be below the average WEP and a variable tariff often set above the WEP. **WEP** Wholesale electricity price. **PV** photovoltaic. **FIT** feed-in tariff.

Sources: Appendixes B, D–G, H–J.

Preferential loans and guarantees

Preferential loans reduce the cost of borrowing to invest in low-emissions generation technologies. These can be in the form of low or zero interest rate loans, or loan guarantees where the government takes on the default risk.

A wide range of preferential loan schemes operate at the national or sub-national level in most of the study countries. These can provide small-scale support (such as the Indian Government's Off-grid and Decentralised Solar program that provides low interest loans for small solar power generation), or large-scale assistance (such as the US Government's Loan Guarantee Program for emissions-reduction projects with total costs over US$25 million).

Low-interest loans and loan guarantees may appear to increase the availability of capital for low-emissions generation projects. However, they do represent costs to government. The difference between the market cost of borrowing and the preferential interest rate is financed by the taxpayer. In cases where guaranteed loans are not repaid, governments may incur large liabilities.

Emissions trading schemes

Two study countries have implemented ETSs that are specific to their electricity sectors. Ten US states are party to a regional cap-and-trade ETS that applies solely to electricity generation. In Australia, the New South Wales Government operates a baseline and credit ETS for emissions in the electricity sector above a benchmarked target (box 2.2). Cross-sectoral ETSs in Germany and the United Kingdom (through the European Union ETS), and New Zealand, also cover electricity generation (section 2.2).

Box 2.2 Emissions trading schemes specific to electricity generation

US Regional Greenhouse Gas Initiative

The Regional Greenhouse Gas Initiative is a state-based cap-and-trade emissions trading scheme (ETS) covering ten north-western US states (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont). The Regional Greenhouse Gas Initiative commenced in 2009, and aims to reduce CO_2 emissions by 10 per cent below 2009 levels by 2018. Generators larger than 25 megawatts (capacity) in the participating states must purchase an allowance for CO_2 emissions. The scheme caps CO_2 emissions until 2014, after which the cap will be reduced by 2.5 per cent per year until 2018. The 2011 permit price currently sits at around US$2.05/t CO_2 (A$2.20).

NSW Greenhouse Gas Reduction Scheme

The NSW Greenhouse Gas Reduction Scheme is a baseline and credit ETS for emissions in the electricity sector above a benchmarked amount. The scheme has operated since January 2003. It requires electricity retailers and other buyers or sellers of electricity in New South Wales to meet mandatory emissions benchmarks based on the size of their share of the electricity market. Parties that emit CO_2 at a rate higher than their benchmark targets are required to purchase offsets (a NSW greenhouse abatement certificate) from eligible abatement projects or pay a penalty of A$12.00/t CO_2. The spot price of an abatement certificate over 2010 was around A$5.00/t CO_2. A similar scheme operates in the Australian Capital Territory.

Sources: Appendixes B, D, K.

Fossil fuel taxes

India and Japan impose taxes on fossil fuels, including fossil fuels used to generate electricity. These taxes raise the cost of production (and the retail price) of electricity generated from these energy sources. The taxes implicitly subsidise untaxed sources of electricity generation.

In India, the Clean Energy Tax imposes a levy of Rs.50 (A$1.20)[6] per tonne of coal, lignite or peat, which are domestically produced or imported. The tax revenue is hypothecated to a National Clean Energy Fund established to fund research and development in clean energy technology and environmental remediation programs.

Japan imposes a tax on petroleum and coal products. The tax rates are ¥2040 (A$25.50) per kilolitre of oil, ¥1080 (A$13.50) per tonne of natural gas or petroleum gas, and ¥700 (A$8.75) per tonne of coal. Japan is proposing to progressively lift these tax rates between 2013 and 2015 as part of its environmental tax reform. The rates are expected to rise by 37 per cent for oil, 72 per cent for gas and 96 per cent for coal.

Differential electricity taxes

Electricity taxes may be imposed at rates that depend on the generation technology (for example, lower-emission electricity generation incurs a lower tax rate or an exemption). These types of policies are not widely applied in the study countries. One exception, is the United Kingdom's Climate Change Levy that taxes non-residential users of electricity (fossil fuels such as gas and coal are also taxed but road transport fuels are not). Electricity generated from renewables (such as solar and wind) and approved cogeneration schemes do not pay the tax.

Direct tax incentives

Direct tax incentives provide tax credits for investment in renewable generation, or for the production of renewable electricity. These policies are not widely used in the study countries.

In the United States, national investment tax incentives offer tax credits that provide up-front payments for installed renewable capacity. A production tax incentive also offers renewable generators up to US$0.022 (A$0.024) for each kilowatt hour

6 Conversion of foreign currency values to Australian Dollars (A$) in this chapter used average exchange rates over January to April 2011 (RBA 2011).

produced. In China, a national scheme offers a reduced valued-added tax rate for electricity generated from renewables (including wind, small hydroelectricity and biomass).

Research and development

All countries studied fund a wide range of programs that subsidise the research, development and commercialisation of renewable electricity generation technologies. For example, the UK Marine Renewables Deployment Fund provides £50 million (A$84 million) to support research into wave and tidal technologies, and the demonstration of these technologies.

Most countries also fund the research and development of clean coal technologies. For example, the Australian Government funds the National Low Emissions Coal Initiative — a program that subsidises low-emissions coal research and the construction of demonstration projects. Governments in Germany, India, the United Kingdom and the United States fund a range of similar programs.

Research and development programs for carbon capture and storage operate in Australia, China, Germany, South Korea, the United Kingdom and the United States. In addition, the Australian Government has established the Global Carbon Capture and Storage Institute that aims to accelerate the development of industrial-scale CCS projects internationally. The European Union has committed to funding up to 12 demonstration CCS plants in EU countries (including Germany and the United Kingdom). Some of these programs also fund CCS research in other energy-intensive sectors (such as resource extraction and manufacturing).

2.4 Policy measures specific to transport

Emissions-reduction policies in the transport sectors of the countries studied predominantly relate to road transport. The most widely applied policies concern fuels, and passenger and light commercial vehicles (summarised in table 2.6). Policies targeting heavy vehicles (such as freight transport) tend to be less widely used. There is also a range of transport-related policies that may less directly reduce emissions (such as public transport and freight infrastructure policies). Few countries have policies targeting domestic maritime and aviation emissions. Regulation of international emissions falls under the jurisdiction of the International Civil Aviation Organisation, the International Maritime Organisation, and the United Nations Framework Convention on Climate Change. There are currently no binding agreements on reducing these emissions although negotiations are ongoing

(ICAO 2011; IMO 2011). In the absence of an international agreement, some countries have committed to unilateral action to regulate international emissions. For example, the European Commission has committed to including domestic and international aviation in the European Union ETS from 2012 (EC 2011a).

Fuel policies (road transport)

Fuel policies are taken to include any measure that taxes, subsidises or regulates road transport fuels (such as petrol, diesel and liquid petroleum gas). Fuel taxes and government assistance to biofuels are the most widely applied emissions-reduction policies covering road transport fuels in the study countries.

Fuel taxes

Historically, fuel taxes have been imposed for a variety of reasons unrelated to emissions reductions (such as to fund road construction and maintenance, to fund public transport, or simply to raise revenue for general government purposes). However, fuel taxes can also serve to reduce greenhouse gas emissions by reducing demand for fuel.

All study countries impose fuel taxes at the point of consumption — as an excise amount per litre of fuel or a consumption tax set at a percentage of the value of fuel sales. There are marked differences in tax rates (table 2.7). Generally, broadly based consumption taxes (such as value added taxes and goods and services taxes) are also imposed on transport fuels.

Some countries also impose fuel taxes on the production of fuels. For example, Japan imposes a Petroleum and Coal Tax on imported crude oil and refined petroleum products used to produce transport fuels, while the New Zealand ETS applies to transport fuels and is paid by fuel producers.

Recently, some governments have introduced taxes directly linked to emissions from road transport fuels. For example, the New Zealand ETS applies to transport fuels in addition to the already existing fuel excise (the European Union ETS does not). The Japanese Government has announced an increase in its Petroleum and Coal Tax based on the emissions content of the fuel category. The California Cap-and-Trade ETS (expected to commence in California in 2012 as part of the Western Climate Initiative) will cover transport fuels from 2015. South Korea is considering imposing an economy-wide carbon tax that may apply to transport fuels.

Table 2.6 **Emissions-reduction policies specific to road transport (passenger and light commercial vehicles), by country**

The jurisdictional coverage of a policy may be national (N), sub-national (S) or European Union (EU).

	Australia	*China*	*Germany*	*India*	*Japan*	*NZ*	*South Korea*	*UK*	*US*
Fuel policies									
Fuel taxes	N	N	N	N,S	N	N	N	N	N,S[a]
Biofuel policies									
fuel content mandates	S[b]	S[c]	N	N			N[d]	N	N,S[e]
production subsidies (fuel tax exemptions)	N	N	N	N	N	N	N		N
capital subsidies for fuel producers	S[f]				N				N
Vehicle policies									
Fuel efficiency/emissions standards	N[d]	N	EU		N	N[d]	N	EU	N
Vehicle fuel efficiency labelling	N	S[g]	N	N	N	N	N	N	N
Vehicle technology mandates			EU					EU	N
Differentiated vehicle taxes	N,S[h]		N	N	N		N	N	N
Subsidies for vehicle purchase		N	N	N	N		N	N	N,S[i]
Capital subsidies for lower-emissions vehicle research and manufacture	N[j]		N				N	N	N

[a] Fuel taxes are levied in all 50 US states, the District of Columbia and at the federal level. [b] *The Biofuels Act 2007 (NSW)* sets a mandate for ethanol and biodiesel content in New South Wales. [c] The National Scheme of Extensive Pilot Projects on Bioethanol Gasoline for Automobiles mandates a 10 per cent blend of ethanol in petrol in five provinces (Heilongjiang, Jilin, Liaoning, Henan and Anhui), and cities in Hubei, Shandong, Hebei and Jiangsu provinces. [d] Voluntary scheme. [e] Fuel content mandates operate in nine US states and at the federal level. [f] Victoria provides infrastructure grants for biofuel facilities through the Biofuels Infrastructure Program. [g] Covers ten provinces including Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia and Shandong. [h] NSW, the ACT and Victoria offer discounted car registration and Queensland and the ACT offer discounted stamp duty for lower-emissions vehicles. The Australian Government's luxury car sales tax is imposed at a higher threshold for lower-emissions vehicles. [i] California. [j] The Australian Government's Green Car Fund closed in January 2011.

Sources: Appendixes B, N, O.

Table 2.7 **Transport fuel tax, by country[a]**

At the point of consumption, excluding broad-based consumption taxes, A$ (2010)

	Petrol	*Diesel*	*LPG*
	A$/L	A$/L	A$/L
Australia	0.38	0.38	..
China	0.16	0.13	..
Germany	0.94	0.67	0.14
India	(7.5% plus) 0.68	(7.5% plus) 0.19	(5%)
Japan	0.67	0.40	0.12
New Zealand	0.45	0.003	0.08
South Korea	0.70	0.49	0.21
United Kingdom	0.96	0.96	0.27
United States[b]	0.11	0.12	0.10

a Rates are current as at March 2011 and have been converted to 2010 Australian dollars. **b** Rates are the sum of federal-level fuel excise and the weighted average state-level volumetric tax rate, as of December 2010. **..** Not applicable.

Sources: Appendixes B, O.

Some countries have policies that can counteract the effect of fuel taxes. Fuel subsidies (or fuel-price regulation) provide a subsidy (either on production or consumption) to encourage the production and use of fossil fuels. These policies aim to reduce the cost and expand access to fuels. For example, India and China operate retail-price controls on some fuels, which set the price of fuel paid by consumers. The US Government provides subsidies for the production of compressed natural gas, liquefied natural gas and other fossil fuel products. In Australia, the Fringe Benefits Tax on employer-provided vehicles applies to a reduced taxable value the further a vehicle is driven. A recent government review found that the policy may encourage individuals to travel unnecessary distances, increasing pollution and road congestion (Henry et al. 2010). The Australian Government has since announced it intends to amend the tax to apply a flat tax rate independent of the distance travelled (Swan 2011).

Biofuel policies

The two main biofuels used for road transport are ethanol and biodiesel. Biofuel policies may have objectives in addition to reducing greenhouse emissions (such as regional development and agricultural assistance). The most common biofuel policies in the study countries are fuel content mandates, and fuel production subsidies (usually in the form of fuel excise exemptions). Capital subsidies for fuel refineries are used to a lesser extent.

Fuel content mandates are requirements for a minimum percentage of specified 'low emissions' fuels to be blended with petrol or diesel. For example, in 2010, Germany had a biofuel quota of 3.6 per cent for petrol and 4.4 per cent for diesel (measured by energy content). All study countries, except New Zealand and Japan, use fuel content mandates (table 2.8).

Table 2.8 **Transport fuel content mandates, by country**
(2009, 2010)

Country	*Mandate*	*Biofuel type*	*Application*	*National/ sub-national*	*Voluntary/ mandatory*
Australia	4 per cent (petrol) 2 per cent (diesel)	All	Per cent of total fuel consumption	NSW	Mandatory[a]
China	10 per cent	Ethanol	Per cent blend in petrol	Provincial	Mandatory
India	5 per cent	All	Per cent blend in all fuels	National	Mandatory
Japan	..	..	..	..	..
Germany	3.6 per cent (petrol) 4.4 per cent (diesel)	All	Per cent of total fuel consumption[b]	National	Mandatory
New Zealand	..	..	..	..	..
South Korea	3 per cent	Biodiesel	Per cent blend in diesel	National	Voluntary
United Kingdom	3.25 per cent	All	Per cent of total fuel consumption	National	Mandatory
United States	8 per cent[c]	All	Varies by jurisdiction	National and state	Mandatory

a In practice, exemptions to the mandates have been granted where producers could not meet the required fuel content level using domestically produced biofuels. **b** By energy content. **c** National 2011 Renewable Fuel Standard across petrol and diesel. Additional mandates also apply in several states. **..** Not applicable.

Sources: Appendixes B, N.

Production subsidies provide assistance to biofuel producers in various ways. Assistance most commonly takes the form of an excise exemption on the tax rate paid per litre of standard petrol or diesel for fuels containing biofuel. For example, India provides a full excise exemption on ethanol (up to 5 per cent blends) and on biodiesel (up to 20 per cent blends). In Australia, ethanol and biodiesel are subject to the full fuel excise but producers receive grants that reduce the effective excise

rate to zero.[7] Some countries pay direct subsidies to producers per litre of biofuel. For example, New Zealand pays biodiesel producers up to NZ$0.45 (A$0.35) per litre for biodiesel. All study countries, except the United Kingdom, provide biofuel subsidies or tax exemptions to biofuel producers (table 2.9).

Capital subsidies for fuel refineries that produce 'low-emissions' fuels are less widely applied. Government subsidies may take the form of direct payments, loan guarantees or preferential loans for fuel refineries. For example, the Biorefinery Assistance Program in the United States provides loan guarantees for the development, construction and retrofitting of commercial-scale bio-refineries to produce 'advanced biofuels' (such as cellulosic ethanol).

Table 2.9 **Biofuel production subsidies, by country**

Country	*Policies*
Australia	Biodiesel and ethanol are subject to the fuel excise but producers receive grants reducing the effective excise rates to zero (changes are proposed from December 2010).
China	Subsidies, tax reductions and/or exemptions of the Value Added Tax are provided to ethanol producers. Subsidies differ by province.
Germany	Fuel tax exemption for biofuels.
India	National excise exemption on ethanol (up to 5 per cent blends with petrol) and on biodiesel (up to 20 per cent blends on diesel).
Japan	Fuel tax exemption for ethanol and biodiesel.
New Zealand	Ethanol is exempt from most fuel taxes compared to unleaded petrol. Grants to biodiesel producers based on value of production.
South Korea	Fuel tax exemption for biodiesel.
United Kingdom	..
United States	A range of national and state tax credits for the production of ethanol. Various payments to biofuel producers at federal and state levels.

.. Not applicable.

Sources: Appendixes B, N.

Governments in all countries studied also subsidise the research and development of biofuels, and fund demonstration production projects to varying degrees. For example, the Australian Government funds the Australian Biofuels Research Institute, which coordinates research and development activities, and subsidises the demonstration and commercialisation of biofuel technologies.

7 The Australian Government has proposed phasing out this arrangement from December 2011, and gradually increasing the effective tax rates on biofuels.

Vehicle policies

Fuel efficiency standards are the most widely applied emissions-reduction policy targeting passenger and light commercial vehicles in the countries studied. Differential vehicle taxes, and subsidies for the purchase of lower-emissions vehicles, are also used in many of the countries. Policies targeting heavy vehicles (such as freight transport) tend to be less widely applied.

Fuel efficiency standards

Historically, fuel efficiency standards have been linked with objectives other than greenhouse gas emissions reductions. For example, the first fuel efficiency standards were introduced in the United States in the 1970s as an energy security measure in response to the first oil shock (Energy Policy and Conservation Act 1975 (US)).

Fuel efficiency standards impose a limit on the average amount of fuel that can be consumed by a vehicle for a specified distance travelled. An alternative approach used by some countries to limit fuel use is emissions standards. These impose a limit on the average quantity of CO_2-e a vehicle can emit per distance travelled. (Emissions standards have also been imposed to reduce pollutants that are harmful to human health or the environment, such as lead and sulphur dioxide.) Fuel and emissions standards may apply to individual vehicles or as an average across a manufacturer's fleet. Heavy vehicles are generally not covered under vehicle fuel efficiency or emissions standards. (One exception is the United States, which has introduced standards for heavy vehicles that will apply from 2014.)

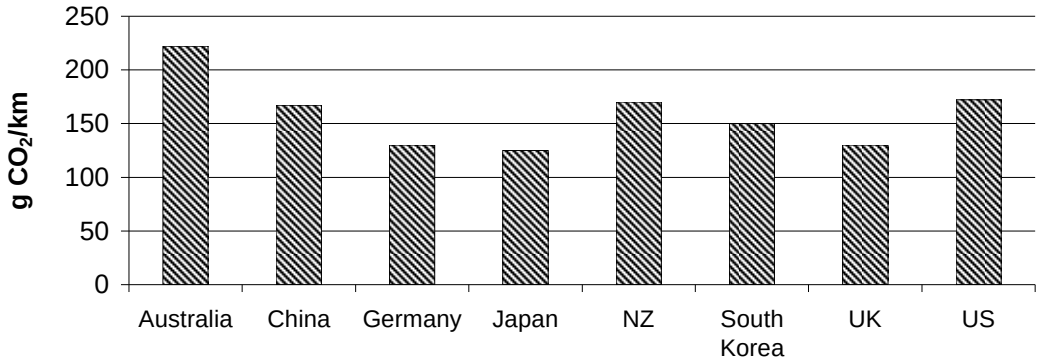
All study countries, except Australia, New Zealand and India, impose mandatory vehicle fuel efficiency or emissions standards (figure 2.2). Australia[8] and New Zealand have voluntary emissions standards. The Indian Government has announced an intention to introduce mandatory fuel efficiency standards in the near future.

Study countries have a range of vehicle policies related to fuel efficiency and emissions standards. For example, all study countries have adopted, or are implementing, fuel efficiency labelling of new vehicles. Some countries use vehicle technology mandates that aim to reduce vehicle emissions in different ways. For example, Germany, the United Kingdom (under European Union mandates) and the United States have tyre standards designed to reduce fuel consumption. The United

8 The Australian Government is considering the introduction of a mandatory scheme (ATC/EPHC Vehicle Fuel Efficiency Working Group 2009).

Kingdom and Germany (also under European Union mandates) limit the use of synthetic greenhouse gases in vehicle air conditioning systems.

Figure 2.2 **Vehicle emissions standards, by country[a,b]**
Grams of CO_2 per kilometre travelled



a Each country's fuel efficiency or emissions standard has been converted grams of CO_2 per kilometre travelled on the New European Drive Cycle. **b** Australia has a voluntary 2010 target for average emissions for all new light-duty vehicles. China has committed to a 2015 target for average passenger vehicle fuel efficiency. The European Union (including Germany and the United Kingdom) has a 2012 target for average fleet emissions with a commitment of 95 gCO_2/km by 2020. Japan requires average fleet fuel efficiency of 16.8 km/L (equivalent to 125 g CO_2/km New European Drive Cycle). New Zealand has a voluntary 2015 target for average emissions for new and used light vehicles. South Korea has committed to a 2015 target for average fuel efficiency with offset credits of up to 10 g CO_2/km available for implementing tire pressure monitoring systems, low-rolling resistance tyres, and gear shift indicators. The United States has committed to a 2016 target for average fleet emissions or fuel efficiency. India does not currently have a fuel efficiency or emissions standard.

Sources: ICCT (2011); Appendixes B, C.

Vehicle taxes

All study countries impose some forms of vehicle taxes. Generally, these take the form of once-off sales taxes and annual vehicle registration fees.

Vehicle taxes have been in place in study countries for a number of years without being explicitly linked with emissions-reduction objectives. However, the level of vehicle taxes often varies with vehicle characteristics that are correlated with emissions (such as engine size, weight or fuel efficiency). For example, most states in Australia set annual car registration fees based on engine size or vehicle weight.

Some vehicle taxes more directly relate to the level of a vehicle's CO_2 emissions. For example, the US Gas Guzzler Tax — introduced in 1978 to discourage the production and purchase of fuel inefficient cars — requires producers or importers

to pay a dollar amount on passenger vehicles with fuel efficiency rating below 22.5 miles per gallon. The tax increases as vehicle fuel efficiency falls — from about US$1000 (A$1090) for 22 miles per gallon (9.4 kilometres per litre) up to a maximum of US$7700 (A$8370) for vehicles of less than 12.5 miles per gallon (5.3 kilometres per litre).

More recently, other study countries have introduced differentiated vehicle taxes based on a vehicle's emissions. For example, Germany and the United Kingdom charge annual vehicle taxes based, in part, on a vehicle's emissions intensity. In Germany the tax rises by €2/g CO_2/km (A$2.70) in excess of 120 g CO_2/km. In the United Kingdom, annual vehicle registration taxes are calculated on average emissions per kilometre. Germany, India, Japan, South Korea, and the United States offer lower sales tax rates or exemptions for electric or lower emissions vehicles. Some states in Australia offer discounted car registration (NSW, ACT and Victoria) and/or discounted stamp duty (Queensland and ACT) for lower emissions vehicles. The Australian Government's luxury car sales tax is imposed at a higher threshold for lower emissions vehicles.

Vehicle subsidies

An alternative approach to reducing taxes on lower-emissions vehicles is to subsidise their purchase. Subsidies can be offered to consumers that purchase specific vehicle types, such as hybrid or electric cars. For example, the UK Government offers a 25 per cent subsidy up to £5000 (A$8380) when purchasing a low-emissions vehicle. China, Germany, Indian, Japan, South Korea, the United Kingdom and the United States also offer such subsidies.

Some study countries encourage the supply of lower-emission vehicles through capital subsidies to vehicle manufacturers (either for the production of particular vehicle types or for research, development and deployment activities). Government subsidies (in the form of grants or loans) can reduce the development or production costs of lower-emissions vehicles. The effect of these types of subsidies on emissions is difficult to discern. They also have the effect of supporting domestic car production and can be seen as a form of industry assistance or trade protection policy.

Among the countries studied, the US Government operates the Advanced Technology Vehicle Manufacturing Loan Program, which funds projects that help vehicles manufactured in the United States meet higher fuel efficiency requirements. The Australian Government's Green Car Fund — closed in January 2011 — subsidised research, development and commercialisation of lower-emission vehicle technologies and their uptake. Major grants provided under the scheme

include A$149 million to General Motors Holden to build the four cylinder car 'Cruze', A$35 million toward Australian production of the Hybrid Camry, and A$42 million to develop a more fuel efficient engine for the Ford Falcon. Germany, South Korea and the United Kingdom also subsidise the development or production of lower-emissions vehicles.

Government fleet policies

Government fleet policies — guidelines or rules on government vehicle purchases and leasing — can include fuel efficiency targets, or quotas for particular vehicle types or fuels. Most countries studied use these types of policies. For example, the US Federal Fleet Management Guidance sets a target to reduce vehicle fleet petrol and diesel consumption by 2 per cent annually, and to increase the use of 'alternative fuel' (biofuels and gaseous fuels) by 10 per cent annually to 2015 (from a 2005 baseline). It also includes mandates for using 'alternative fuel' vehicles and hybrid electric vehicles.

Other land transport-related policies

There are a range of other land transport policies that may less directly result in emissions reductions. Many of these policies have other explicit objectives, and complex and indirect impacts on emissions, making it difficult to attribute emissions reductions to them (chapters 3 and 5). Policies of this kind include:

- *investment in passenger and freight transport infrastructure,* including:
  - *high-speed rail*. For example, China, India, South Korea, the United Kingdom and the United States are investing in new high-speed passenger and/or freight networks connecting large population centres and heavy freight corridors. The Australian Government has commissioned a feasibility study into a high-speed rail network on the east coast of Australia (including consideration of a Newcastle to Sydney 'spine', northward links to Brisbane and southwards links to Canberra and Melbourne (DIT 2011.)
  - *transport infrastructure to encourage modal shifts to lower-emissions forms of transport.* For example, new subway projects are under construction or planned in the Indian cities of Delhi, Chennai, Kolkata and Bangalore. The city of Sydney operates a bus corridor program that has established priority bus lanes on existing roads and bus-only roadways such as the Liverpool-Parramatta T-way rapid transit line. In 2009, the South Korean Government enacted a law expanding the construction of bicycle only lanes.

The UK Government is subsidising the construction of a public plug-in network for electric vehicles.

  - *lower emissions public transport infrastructure.* For example, the UK and US Governments are funding the electrification of fossil fuel powered rail networks. The ACT Government is progressively changing over the Territory's bus fleet to compressed natural gas.

- '*intelligent transport systems'*. For example, Japan is rolling out a national traffic control and information sharing system to reduce congestion and vehicle emissions. The Queensland Government's FreightSmart program encourages alternative freight delivery systems that reduce urban congestion and vehicle emissions.
- *road pricing and road use policies*, including:
  - *congestion pricing.* For example, the city of London charges a fee for vehicles entering central London between 7 am and 6 pm weekdays. Toll charges on the Sydney Harbour bridge rise during morning and afternoon peak periods, and fall overnight and during the day.
  - *road tolls based on fuel efficiency and distance travelled*. For example, Germany charges a truck toll for freight vehicles based on the distance travelled, the size of the truck and its emissions category.
  - *rationing and auctioning of vehicle licences.* For example, the city governments in Beijing and Shanghai cap the number of new vehicle licences issued in a month and auction them off.
  - *high-occupancy lanes and/or low-emissions vehicle-only lanes*. For example, Melbourne's Eastern Freeway has a high occupancy vehicle lane during morning peak times. In some US states, low-emissions vehicles are permitted to use high occupancy vehicle lanes with only one person in the car.

Aviation and maritime policies

There are currently no multilateral agreements covering international aviation and maritime emissions. Negotiations (between national governments, the International Civil Aviation Organisation, the International Maritime Organisation, and the United Nation Framework Convention on Climate Change) on how international transport emissions will be counted, and what steps may be taken to reduce them, are ongoing (ICAO 2011a, IMO 2011).

In the absence of an international agreement, the International Maritime Organisation has developed a range of technical and operational energy efficiency

measures for new and existing ships designed to reduce emissions, and is negotiating with member countries to make the measures mandatory (IMO 2011). The International Civil Aviation Organisation is coordinating a range of voluntary measures to reduce aviation emissions (such as increased fuel efficiency of aircraft, the development of aviation biofuels and offset markets for aviation emissions, and improvements to air navigation practices (ICAO 2011a)).

Some of the countries studied have taken policy action to reduce domestic aviation or maritime emissions. For example, the New Zealand ETS covers transport fuels used for domestic flights and shipping (fuel used by international aviation and marine transport is exempt). The Japanese Government has imposed a Petroleum and Coal Tax on imported crude oil and petroleum used to make transport fuels (including aviation and maritime fuels). This tax is to be progressively increased from 2013 to 2015 (although petrol, light oils and jet aviation fuels will initially be exempt).

Some countries have taken unilateral policy action to cover international emissions that otherwise would have been be covered under multilateral agreements. These policies are examples of businesses being subjected to the policies of foreign governments. For example, the United Kingdom imposes an air passenger duty (charged to the carrier) on flights departing the United Kingdom. The rate of the duty increases with the distance flown. The European Commission has committed to including domestic and international aviation (covering aircraft that arrive or depart from EU airports) in the European Union ETS from 2012 (EC 2011a). The European Commission has also publicly stated that the European Union will bring all international shipping visiting EU jurisdictions into the ETS if there is no global agreement on maritime emissions by the end of 2011 (EC 2011b).

There is a range of policies in the countries studied that support research and development in relation to aviation biofuels. For example, the US Federal Aviation Administration (in partnership with the aviation industry) funds the Continuous, Lower Energy, Emissions and Noise Reduction Program to develop aviation biofuels. The US Air Force is undertaking tests with private sector companies to meet a goal of certifying all of its aircraft as able to use aviation biofuel blends, and to be able to obtain 50 per cent of its aviation fuel needs from biofuels by 2016. The US and Chinese Governments have signed a series of research partnerships between the Boeing Company, US government agencies, and Chinese research institutions and state companies to undertake aviation biofuels research (ICAO 2011b). The European Union funds a range of aviation biofuel research programs, including Sustainable Way for Alternative Fuels and Energy for Aviation (SWAFEA 2011).

2.5 Forestry and agriculture

Forestry

Many of the study countries have made public commitments to emissions-reduction policies in the forestry sector. Some policy commitments appear be aspirational targets to increase the land area covered by forest or to increase forest stock. Other policy commitments involve the use of financial incentives and land-use regulations to increase forestry coverage and reduce emissions from land clearing.

For example, the National Mission for a Green India program — one of the eight programs under the National Action Plan on Climate Change — aims to increase forest cover on a total of 10 million hectares of land, and to increase CO_2 sequestration in forests by 50 – 60 Mt per year by 2020. It is currently unclear how these targets will be achieved. The Indian Government has allocated A$2.72 billion to a Compensatory Afforestation Fund Management and Planning Authority to fund programs for the conservation, regeneration and management of existing forests and wildlife habitats. Details on how the money will be used are currently unclear.

China has adopted an aspirational target to increase forest cover by 40 million hectares, and forest stock volume by 1.3 billion cubic metres by 2020 from 2005 levels. It is unclear how these targets will be achieved.

The Australian Government offers a tax deduction to businesses that plant forests for the purpose of absorbing CO_2 from the atmosphere. Some state government policies also encourage the expansion of forestry coverage (such as Victoria's Carbon Tender which pays landholders to permanently revegetate a portion of their land) or emissions reductions through changes to land management practices (such as Queensland's *Vegetation Management Act* (1999) that regulates land clearing).

New Zealand has three main schemes that subsidise afforestation and the maintenance of existing forests. The East Coast Forestry Project subsidises the planting of commercially productive forest (up to 200 000 hectares by 2020). The Afforestation Grants Scheme provides finance to smaller landholders for planting new forests. The Permanent Forest Sinks Initiative encourages the establishment of permanent forests on previously unforested land by granting landholders tradable offset credits that they can sell on the domestic or international carbon markets.

The United Kingdom operates a number of schemes (such as the Woodland Grant scheme and the Environmental Stewardship scheme) that provide financial incentives for landowners wanting to create new woodland or improve land management practices.

The US Government and some state governments operate a range of policies that provide financial incentives and technical assistance for voluntary sequestration of emissions by private land owners.

Forestry sectors in some of the countries studied are covered by ETSs. The New Zealand ETS has applied to forestry since its inception in 2008. The owners of eligible forests can receive emission permits for increases in the carbon stock of their forest and can trade these on the domestic emissions market or convert them to Kyoto units to be traded overseas. Forest owners are required to surrender New Zealand Units to the Government if carbon stocks fall (for example if a forest is harvested). Units earned from forestry sequestration can be traded internationally to meet obligations under the Kyoto Protocol. In addition, the US Western Climate Initiative cap-and-trade scheme, in principle, will permit offsets from forestry activities. The European Union ETS does not currently cover forestry.

Agriculture

Agricultural food production (including cereals, grains, meat and dairy) can be a significant source of a country's overall greenhouse gas emissions. Currently, it appears there are few emissions-reduction policies that apply to the agricultural sectors of the countries studied.

China and South Korea have announced policies to reduce emissions from rice growing. However, there is little detail on how these targets will be achieved.

A number of countries fund research into reducing agricultural emissions. For example, Australia and New Zealand have a range of policies that fund research into reducing emissions from various farming activities. The UK Government funds research into reducing methane emissions from dairy cattle. Japan operates a national program studying potential uses for biomass from the agriculture and forestry sectors. A draft law before the Japanese legislature would set targets for the proportions of biomass (such as cattle excrement, food waste, wood waste and forestry residue) to be re-utilised by 2020.

Existing ETSs deal with agricultural emissions in different ways. The New Zealand ETS will require the agriculture sector to report emissions from 2012 (with agriculture scheduled to be covered from 2015). Agriculture will receive uncapped permit allocations on an output intensity basis. Agricultural activities cannot currently earn New Zealand Units for sequestration of emissions. The Western Climate Initiative cap-and-trade scheme, in principle, will permit offsets for agricultural activities. The European Union ETS does not cover agriculture.

The Australian Government has introduced legislation to parliament to establish a national Carbon Farming Initiative — a voluntary scheme that would enable farmers, forest growers and other landholders to earn carbon credits for saving or storing greenhouse gases through eligible sequestration activities (DCCEE 2011b).

2.6 Energy efficiency

All study countries use a wide range of policies designed to increase energy efficiency, many of which are promoted as contributing to emissions reductions. Energy efficiency policies apply to households, businesses and government operations in the countries studied. Appendix C discusses some of the major energy efficiency policies in electricity consumption and road transport in more detail. Further information on specific energy efficiency policies is provided in the country stocktakes on the Commission's website (appendix P). Energy efficiency policies that relate to road transport are also discussed in section 2.4.

The most widely applied policies aim to reduce household and commercial energy consumption through:

- *information provision.* All study countries operate energy efficiency labelling schemes for certain electrical appliances (such as energy efficiency star rating labels on household appliances). Some countries also operate energy efficiency rating schemes for residential and commercial buildings that require disclosure of the building energy efficiency rating prior to rental or sale.
- *minimum standards.* All study countries set minimum energy efficiency standards for specific electrical appliances. Generally, appliances that do not meet these standards can not be sold in the country. Study countries also set energy efficiency related building standards for residential and commercial buildings through their respective building codes and regulations (covering areas such as insulation, heating, cooling and lighting).
- *direct financial assistance.* Governments may provide zero or low interest loans, or product subsidies and rebates, to encourage the purchase of energy-efficient electrical appliances and the installation of energy efficiency building measures.
- *market-based schemes.* Governments can require electricity retailers to meet energy savings targets by encouraging the uptake of energy efficiency measures by residential customers or by purchasing offset certificates.

Study countries also operate a range of energy efficiency policies that specifically target energy use by businesses. Primarily, these policies relate to electricity use,

but can include other energy sources such as oil, gas, coal and biomass. Policies fall into three broad categories.

- *Information and financial assistance to small and medium businesses to reduce energy use.* Voluntary programs can offer information and subsidies to encourage the uptake of energy efficiency measures by businesses. For example, the UK Carbon Trust and Low Carbon Australia are non-profit companies established with seed funding from their respective governments. They provide information and advice to businesses and the public sector on how to reduce energy use, and subsidise the uptake of energy-efficient technologies. All countries studied offer a range of these policies.
- *Partnership programs for 'large' energy users.* These policies can include voluntary or mandatory energy (or emissions) reporting, energy audits of business operations, and the uptake of energy efficiency measures. Australia, China, Japan, South Korea and the United States operate these types of programs.
- *Market-based mechanisms for 'large' energy users.* Market-based mechanisms usually set a cap on energy use or an energy efficiency target for businesses, then impose a penalty for not achieving targets (such as a fine or requirement to buy an offset certificate). A number of countries have implemented, or are considering, these types of schemes (box 2.3).

Study countries also target energy efficiency in government operations. This can be through energy audits to identify energy efficiency opportunities, the mandating of energy efficiency targets, and government procurement policies which set minimum energy efficiency standards for government purchases of goods and services (such as minimum fuel efficiency standards on car fleet purchases). All study countries have incorporated energy efficiency objectives into aspects of their government procurement policies.

Box 2.3 **Market-based energy efficiency schemes for business**

In the countries studied, a range of market-based schemes that aim to improve energy efficiency in business operations are in use or about to be implemented.

- *The Tokyo Metropolitan Government's baseline and credit trading scheme.* The mandatory scheme (commenced in 2010) covers emissions from the energy consumption of approximately 1400 office buildings and 300 factories (about 20 per cent of Tokyo's emissions). The scheme aims is to reduce emissions by 25 per cent by 2020 from 2000 levels. Covered installations are set emissions targets based on energy consumption and must buy offsets or pay a fine for energy consumption above the target. Saitama Prefecture operates a similar scheme.
- *The Indian Perform, Achieve and Trade scheme.* The scheme (to commence in April 2011) requires approximately 700 of the most energy intensive industrial units and power stations in India to reduce their energy intensity by a specified percentage (depending on the current level of efficiency). Energy users that achieve reductions above their mandated amount receive Energy Savings Certificates that can be traded. The firms included in the scheme are responsible for around half of India's emissions.
- *The South Korean Greenhouse Gas and Energy Target Management Scheme.* The scheme (to commence in 2012) is a system of mandatory agreements covering companies producing at least 25 000 metric tons of emissions a year (470 companies, including 36 power generators). The agreements would set energy savings and emissions-reduction targets for each emitter. Emitters who would have to buy offsets or pay a fine for not meeting a target.
- *The NSW Energy Savings Scheme.* The scheme (commenced in 2009) is a mandatory energy efficiency scheme for electricity retailers who are required to meet energy savings targets. Electricity retailers meet their targets by implementing energy saving activities (with households and business customers) or by purchasing energy savings certificates from companies with recognised energy reductions.

Source: Appendix P.

3 Methodology

Key points

- What all emissions-reduction policies have in common is that they generally impose costs that someone must pay in order to reduce emissions. It is in this sense that the Commission has interpreted 'effective' carbon price loosely to mean the cost of reducing greenhouse gas emissions. This applies both to individual emission-reductions policies and in aggregate.
- The Commission has adopted a partial equilibrium, comparative static approach that compares, in the latest year for which data are available, a snapshot of the post-policy situation to the counterfactual snapshot of no policy. Ideally the impacts would be measured in terms of changes in economic welfare, taking into account influences on both the supply and demand sides, divided by the abatement achieved.
- On the supply side, the Commission has estimated subsidy equivalents as proxies for resource costs. The subsidy equivalent is the amount of explicit or implicit subsidy provided for low-emission products.
  - While it overstates the resource costs involved, this measure provides some basis for comparing the cost-effectiveness of different policies within and across countries.
  - Subsidy equivalents are also useful indicators of the resources that respective governments are prepared to devote to encouraging abatement, either directly through explicit financial subsidies or indirectly through higher prices paid by consumers.
- On the demand side, the Commission has also endeavoured to estimate the overall product price 'uplift' that results from the various supply and demand-side interventions in each sector for each country, and using this information make some inferences about consumption costs and demand-side abatement.

The terms of reference for this study essentially ask the Commission to capture the various emissions-reduction policies being applied in a number of countries in a single metric — an 'effective' carbon price. This would be a relatively straightforward task if all countries applied economy-wide carbon taxes or quota schemes.

In that case, the carbon 'price' would be observable and comparable. But, as chapter 2 has illustrated, none does, eschewing broadly-based explicit pricing for a myriad of less transparent, more narrowly-focused interventions designed to assist the production and consumption of selected, less emissions-intensive technologies, or penalise particular emissions-intensive products and processes. Even those countries that have carbon pricing schemes apply them only to a limited range of emitting activities. This fragmented approach increases the cost of achieving any given level of abatement, but it also makes comparable measurement problematic.

This chapter discusses the methodology used in this study. Section 3.1 outlines how emissions-reduction policies work and section 3.2 looks at measurement issues. Section 3.3 then considers summary measures. Some key terms used in this study are outlined in box 3.1.

Box 3.1 **Subsidy equivalent, abatement and cost terminology**

- *Production subsidy equivalent* — the assistance provided per unit of output through a particular policy measure (implicitly or explicitly) to suppliers of low-emissions, but high cost, products to enable them to be competitive with high emission but low cost products.
- *Subsidy equivalent* — the production subsidy equivalent multiplied by output.
  - The *total subsidy equivalent* is the sum of the subsidy equivalents at the sectoral level.
- *Abatement* — a reduction in greenhouse gas emissions. In this study abatement has been calculated by comparing the emissions of the low-emissions product or technology supported by a policy measure with the emissions of the counterfactual high-emissions product or technology.
  - *Total abatement* is the sum of abatement from all policies at the sectoral level.
- *Implicit abatement subsidy* — the subsidy equivalent divided by the amount of abatement. An indicator of relative cost effectiveness.
  - The *average implicit abatement subsidy* is the total subsidy equivalent divided by total abatement.
- *Resource costs* — the value of labour, capital and other primary factors of production used directly and indirectly in the production of a good or service.
- *Consumption costs* — households' valuation of the goods that they give up as a result of a price rise, less their valuation of other goods that are purchased with the diverted expenditure. (When a tax on a good increases its price, households use less of the good than they would otherwise prefer and divert more expenditure to other, less-preferred goods.)

3.1 How emissions-reduction policies work

Understanding how different policies operate is an important first step to measuring and aggregating their effects.

'Carrots and sticks'

Despite the variety of policy instruments, all policies designed to promote lower greenhouse gas emissions essentially must either provide incentives to abate or disincentives to emit greenhouse gases, or both. Broadly speaking, all policies can be classified as those that:

- encourage substitution of low-emissions technologies and products (for example, renewable electricity and biofuels) for higher-emissions technologies and products (such as coal-generated electricity and fossil fuels) — these policies essentially focus on the production or supply side
- discourage consumption of products that generate emissions, either through price increases of those products and/or non-price induced decreases in demand for emissions-intensive products — these policies work through the demand side.

But whichever side of the market policies target, they will have implications for the other. Policies that effectively tax one commodity implicitly subsidise others. Effective subsidisation of a commodity implicitly taxes others. Put another way, to achieve their objective, policies that seek to reduce greenhouse gas emissions must alter relative prices to favour products that involve low emissions and to discourage products with the opposite characteristics.

Carbon taxes and quotas

It is generally recognised that the most direct and, consequently, most efficient way of implementing the 'relative price' change required to discourage consumption of high-emission products in favour of low-emission ones, is through a global, broadly-based carbon tax or quota scheme (emissions trading scheme). Placing a 'price' on emissions through these mechanisms means that an additional cost must be taken into account in all decisions involving production and consumption of competing products that have varying amounts of emissions embodied in them or which emit varying amounts of carbon in their use. Production of emissions-intensive products will decline as consumers reduce their purchases in response to higher prices, and as producers switch to comparatively cheaper, low-emission production technologies and intermediate inputs. Because these adjustments can be made on the basis of consumer and producer assessments of

relative costs and benefits to them, any given amount of abatement will be achieved at least cost.[1]

Emissions trading schemes (ETSs) limit the total quantity of emissions, but in effect work in a similar fashion to taxes, by directly raising energy prices to consumers and implicitly subsidising producers of 'clean' products. Therefore, any ETS has a 'tax equivalent' that would deliver precisely the same amount of abatement from the same sources for the same resource cost. Assuming perfect compliance, the two approaches also would have identical distributional impacts, delivering the same revenues to government, if permits were auctioned.

However, no country currently imposes an economy-wide tax on greenhouse gas emissions or has in place an economy-wide ETS. Of the study countries, the United Kingdom, Germany, some parts of the United States and New Zealand have emissions trading schemes operating — but these apply only to particular sectors, such as electricity generation. In some cases too the imposition of generous caps, combined with the impacts of economic recession, have meant that, at least in the early years, the caps have not been binding to any great extent and prices of emission permits have been low (for example, the Regional Greenhouse Gas Initiative in the United States).

Emissions trading schemes or taxes that focus on the electricity sector alone nevertheless work in the same way as more broadly-based taxes and quotas, though the potential abatement options are more limited. They increase the price of non-renewable energy and reduce energy consumption overall (assuming some price sensitivity of demand).[2] At the same time, they implicitly subsidise lower emissions-intensity energy production, because they raise the price that renewable energy producers can charge energy buyers (and still compete with other producers). Non-renewable energy production will thus be squeezed on two 'margins' — by lower demand for energy overall, and by the increased competitiveness of renewable energy production.

An emissions tax in the electricity sector effectively taxes consumption of *all* energy. The revenue raised from taxation of high emissions-intensity energy production accrues to government, and the revenue from higher prices for low

1 This presumes that the tax or quota scheme is costless to implement. In practice, the costs of administration and compliance would make it uneconomic to attempt to cover all goods and services in all situations, and hence price effects will differ. However, to the extent that such exemptions are based on marginal benefits and costs, the resulting consumption patterns would be optimal from the community's perspective.

2 Reductions in energy consumption could be countered by compensation payments, particularly arrangements linked to energy use, such as rebates rather than lump-sum income supplements.

emissions-intensity energy production accrues to producers as an effective subsidy (box 3.2). The rate of subsidy, or producer 'price uplift', for renewable production is equal to the rate of tax on emissions-intensive production.

Subsidies, renewable targets or mandated production standards

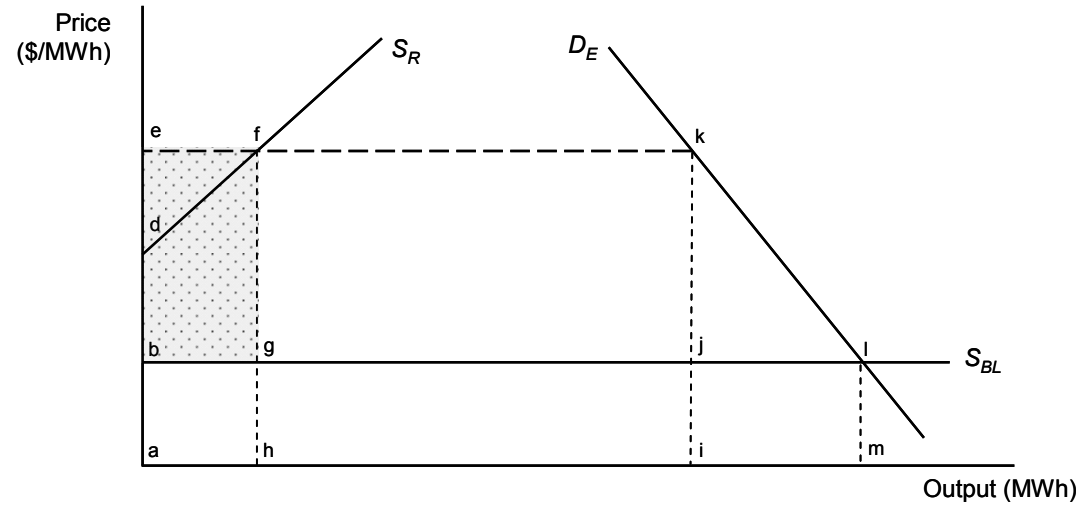
Chapter 2 sets out an extensive range of policies that subsidise the production or consumption of particular 'clean' technologies, or that mandate targets for the use of these technologies by producers.

Regulations or schemes that set quotas, standards or targets for renewable energy, or which mandate prices for generating certain types of renewable energy (such as solar feed-in tariffs), implicitly subsidise their production (box 3.3). In this case, the subsidy rate is equal to the producer price uplift required to induce the amount of renewable energy set by the target or quota. The 'subsidy equivalent' of a policy will equal this subsidy rate times the quantity of renewable energy produced.

Except for explicit, taxpayer-funded subsidies, such schemes must also 'tax' consumers to pay for the higher cost of supplying energy from renewable technologies. Higher energy prices in turn will induce some reduction in overall energy use, leading to some additional abatement. To the extent that energy consumers were compensated for the additional energy cost, this additional source of abatement could be diminished, depending on the nature of the compensation payment.

It is important to note, however, that even if the full costs of implicit production subsidies are passed on to energy consumers, the resultant increase in the price of energy will not have the same effect as imposing a tax on emissions that led to the same uplift in consumer prices. Such a tax would induce different, lower-cost abatement and, almost certainly, would generate different levels of abatement (higher or lower) than the renewable target.

Box 3.2 **How emissions taxes and permits work**



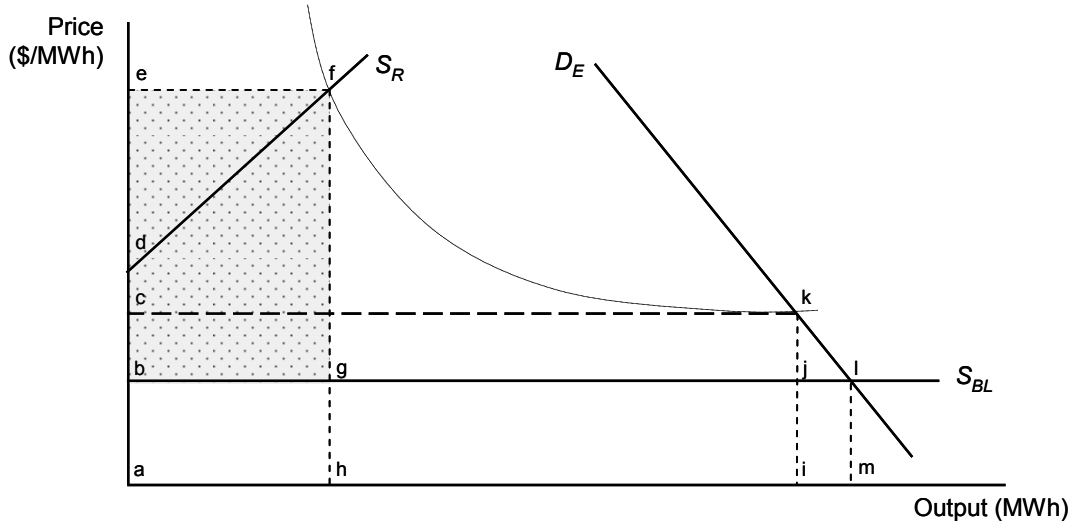
This figure presents a stylised market for electricity generation with non-renewable baseload electricity being provided at a constant unit cost equal to price *ab*, and no renewable electricity generation (represented by the supply curve S_R). A carbon tax is then imposed, driving up the price of electricity from *ab* to *ae*.

This higher price will have two effects. One, household and business demand for energy falls (from *am* to *ai*) (they use less energy either through adopting more energy efficient processes or by curtailing activities and production that use energy). Two, at the same time, provided the tax is high enough, energy generated from renewable or less emissions-intensive sources will come on line in response to the higher consumer price for energy from non-renewable sources (as drawn, supplying *ah*).

Amount *hi* is still supplied from non-renewable energy sources. Tax revenue collected from non-renewable energy production is represented by area *gfkj*. A quota or permit scheme that only allowed total emissions consistent with this output from non-renewable sources would have the same price and abatement effects as the tax, but the distribution of the revenue represented by area *gfkj* will depend on whether permits or quota entitlements are given away or sold.

Shaded area *befg* represents the 'subsidy equivalent' to renewable energy producers, paid by consumers of energy. The economic costs of the scheme are the additional *resource cost* of producing renewable energy (area *bdfg*) plus the *consumption cost* (the loss of consumer surplus represented by triangle *jkl*). Consumers, however, not only curtail their energy consumption, but pay more for what they continue to consume — in total, area *bekj*, which comprises tax payments to government (or payments for permits) and the 'subsidy' to producers of renewables.

Box 3.3 **How subsidies and renewable energy targets work**



This figure again depicts a stylised electricity generation market, with non-renewable baseload electricity being provided at a constant unit cost equal to price *ab*, pre-intervention. Total consumption is *am*. A mandatory renewable energy target is introduced that is assumed to induce supply from low-cost (for example, biomass), medium-cost (wind) to high-cost (solar) sources. The supply curve for these options is shown as S_R. If the renewables target is set at quantity *ah*, the price required by marginal generators will be *ae*.

- The implicit subsidy paid per MWh to renewable producers is *be*, and the total subsidy equivalent (*TSE*) the shaded area, *befg*. Total abatement would be equal to the difference in emissions intensities of the baseload generator and the renewable generators, multiplied by the amount of renewable electricity *ah*.
- Part of the *TSE*, area *def*, is producer surplus to renewable suppliers — the size of this depends on the excess of the price received over their costs of production. The remainder (area *bdfg*), is the additional resource cost of supplying *ah* (that is, additional to the cost of the baseload generation being replaced).

The renewables target will increase the average cost of generating electricity and lead to an increase in the electricity price from *ab* to *ac* (as drawn, the full cost of the subsidy is passed on to consumers so area *befg* is the same as area *bckj*). This will induce a reduction in consumption of energy and some additional abatement. If the subsidy to renewable energy producers was paid by taxpayers instead, the consumer price of electricity would not change, but the average cost of producing energy would still rise.

Biofuel policies

There are a range of assistance measures designed to increase the production of biofuels and displace the consumption of cheaper but more emissions-intensive

conventional fuels (petrol and diesel). These include production subsidies as well as fuel content mandates that specify a minimum percentage of biofuel in the volume of petrol or diesel sold. The mandated increase in demand allows biofuel producers to sell at a higher price than conventional fuels (adjusted for energy content) and thus provides an implicit subsidy for their production (box 3.4).

Fuel taxes

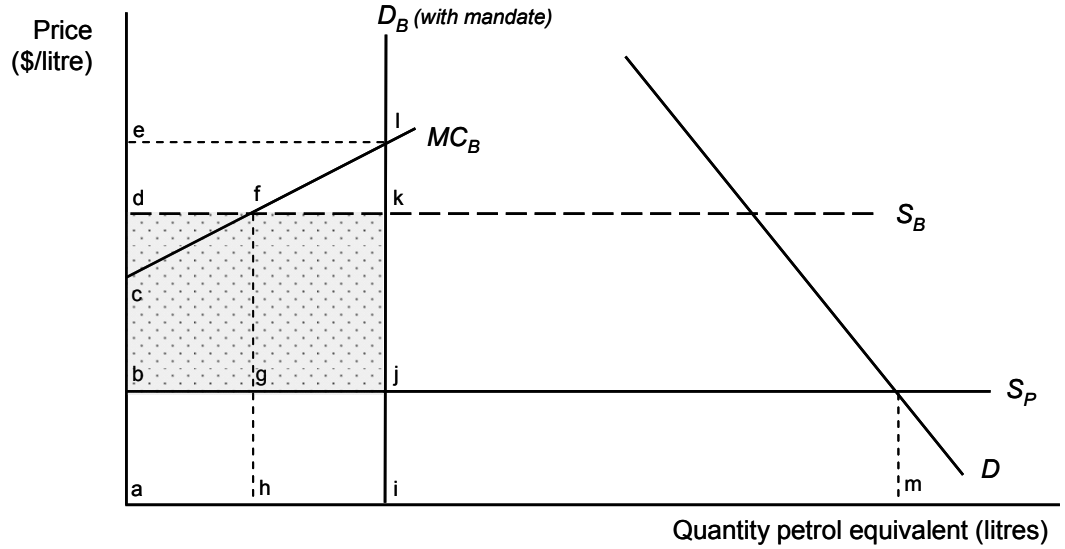
Fuel taxes raise the price of fuel and therefore reduce fuel consumption and greenhouse gas emissions from fuel use. Thus they result in abatement on the demand side. As with supply-side abatement there is a cost, but in this case it is less obvious than the additional resource costs that are involved in supply-side abatement. With demand-side abatement, consumers end up driving less and diverting more of their expenditure to other goods than they otherwise would prefer. Measurement of this consumption cost requires assumptions about the demand curve and how responsive consumers are to increases in fuel prices.

Energy efficiency measures

In addition to policies that increase prices of energy products, there are many policies designed to compel or encourage consumers and firms to invest in more energy-efficient durable products, such as fuel-efficient cars and energy-efficient appliances. The switch to such products is intended to reduce the demand for energy and, hence, emissions. However, the ultimate impact on emissions will also be a function of the level of their use. Because the energy operating costs are reduced, 'rebound' effects can mean usage can increase, offsetting some of the initial savings. Further, the effect on abatement in some instances will depend on the emissions intensity of energy or fuel production displaced — higher-cost renewable products could be displaced instead of cheaper but more emissions-intensive products.

There are substantial difficulties in evaluating these programs and calculating their effects. There are resource costs in producing the additional energy-efficient durables, but there are also expected future savings in resource costs from using less energy (box 3.4). And both the additional production costs and the expected future cost savings are difficult to measure.

Box 3.4 **How fuel content mandates work**



This figure depicts a market where both petrol and biofuel can be supplied by imports at world prices *ab* and *ad* and the two are considered to be perfectly substitutable in use after adjusting for energy content. Without intervention, *am* litres of petrol are consumed and no biofuel is consumed as it is not competitive with petrol.

Consider the introduction of a binding fuel content mandate that requires demand for biofuel to be *ai* and allows this to be met by imports or domestic production. The domestic biofuel price is set by the world price and the quantity of domestic production depends on its marginal costs MC_B. At price *ad* domestic production of biofuel is *ah* and imports are *hi*. The additional costs required to replace petrol with biofuel are *bcfkj* which are the additional resources used in producing domestic biofuel *bcfg* and to purchase the biofuel imports *gfkj*. The subsidy equivalent of the biofuel mandate is the shaded area *bdkj*, which is greater than the additional resource costs by the value of producer surplus *cdf*.

In contrast, where imports are not permitted to meet the mandate *ah*, the price that domestic biofuel producers receive will reflect domestic costs of production. That is, the price will be determined by domestic producers' marginal cost at the mandated quantity of biofuel. In this case, with domestic biofuel price *ae* domestic production of biofuels is *ai*, the total subsidy equivalent is *belj*, the additional resource costs are *bclj* leaving producer surplus *cel*.

Although not shown in the figure, the fuel mandate also increases the price of the petrol-biofuel blend and thus also has demand-side effects.

The difficulty in measuring production costs of additional energy efficiency is that energy efficiency products generally do not exist on their own. Instead, energy efficiency attributes are embodied in durable products along with other attributes.

Measuring the expected decrease in future energy costs is also difficult, because it depends on whether investors underestimate the benefits of energy savings

(box 3.5). The 'energy paradox' is that there appears to be a reluctance to invest in seemingly cost-effective energy-efficient durables. Why this is so is contentious. The net result depends on whether the apparent reluctance reflects investor misperceptions, or whether it reflects some unobserved cost of additional energy efficiency (such as search costs, high borrowing costs, or a preference for product attributes other than energy efficiency).

Therefore, the net costs of efficiency standards depend critically on assumptions regarding investor perceptions. For example, Parry, Evans and Oates (2010) provided estimates suggesting that in the United States, the marginal costs of using auto standards to reduce economy-wide emissions by several percent can vary from roughly –US$100 to +US$100 per US (short) ton of CO_2.

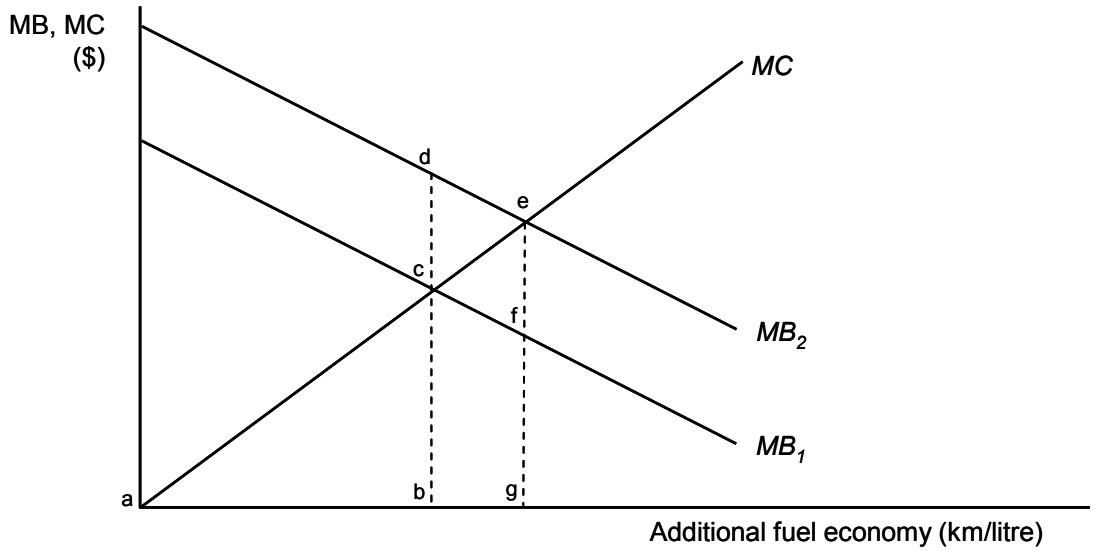
3.2 Measurement issues

The crux of the challenge for this study is how disparate, limited policies of selective application can be measured and aggregated in a useful way. If all greenhouse gas emissions were 'priced' directly, comparing prices across countries would be meaningful. Even so, any differences in carbon prices would not reveal whether some were too high or some too low — that would require an assessment of the desirable level of abatement globally. Some differences would also occur where the coverage of schemes differed.

In the absence of explicit carbon prices or taxes being imposed on all emissions in an economy, the total economic (welfare) costs of individual policies and their associated abatement effects ideally need to be estimated.[3] Measurement of total costs and abatement would allow calculation of average costs per tonne of CO_2 abated *under the schemes analysed*, which in turn would allow comparison of the cost-effectiveness of the various policies.

3 Price and quantity adjustments induced in markets will also likely generate real adjustment costs involving capital write-offs and labour relocation. Implementation and ongoing administration and compliance costs should also be taken into account but are difficult to measure.

Box 3.5 **How energy efficiency standards work**



A large number of policies promote the production of and investment in more energy-efficient durable products, buildings and equipment, with the objective of reducing the demand for energy. The above figure is a stylised representation of the marginal benefits and costs of investing in a durable product (a car) that gives greater fuel economy. Marginal costs represent the resource costs used in producing the product, whereas the marginal benefit to investors depends on the value of expected future fuel savings discounted over the product lifespan (less any other transaction costs).

Expected fuel costs are the discounted value of the expected distance travelled in each future year, multiplied by the expected price of petrol divided by the fuel economy (km/litre). Marginal benefits are the change in fuel savings (that is, the negative of the change in expected fuel costs) from a change in fuel economy. With higher petrol prices, greater distance travelled and/or a lower discount rate, there are larger marginal benefits.

Many studies have suggested that buyers seemingly undervalue increased fuel economy. That is, marginal benefits are perceived to be MB_1 rather than the 'true' MB_2 and actual investment *ab* is less than the desirable level *ag*. This 'energy paradox' could result from imperfect information or excessive discounting. In this case, a mandatory vehicle fuel economy standard *ag* is seen as achieving the desired production level and net benefits — the increase in production costs *bceg* is less than fuel savings *bdeg* giving net benefits *cde*.

However, if investors correctly evaluate fuel savings, then marginal benefits are represented by MB_1 and a mandated fuel economy standard *ag* results in additional production costs *bceg* less fuel savings *bcfg*. In this case, the vehicle fuel economy standard leads to over-investment in fuel economy with net costs *cef*. Thus, the costing of mandated energy efficiency standards such as fuel economy is particularly problematical and depends critically on the assumption about the extent to which investors may misperceive costs and benefits (to themselves).

An inherent difficulty of these measurements is that they involve comparing an existing situation with an unobserved 'counterfactual'. Calculating the effects of an existing or committed policy requires an assessment of what would have happened in the absence of the policy. This requires assumptions about, or estimates of, the supply and demand responses to the policy. Yet there is often considerable uncertainty about these responses, and the underlying models that are used to measure them can be quite different (and are sometimes only implicit). Some models are based on engineering estimates with little behavioural response, whereas others allow for behavioural supply and demand responses.

These considerations are especially important when attempting to construct comparable measures across diverse policies and countries. In some cases, sophisticated models allow consistent measurement across policies in a single country,[4] but for most there are no available models, and also significant data limitations. Costs of a policy derived from even a fully-specified model in one country will not be comparable to those calculated from more ad-hoc methods in another.

For policies that assist producers of low-emission products, the value of the assistance ('subsidy equivalent') is more easily calculated than their resource costs and is more comparable across policies and countries. These production subsidy equivalents[5] are of interest in themselves, because they capture the often hidden transfers to producers. Also, they are indicative of the true (resource) costs, though they generally will overstate them.

Measuring economic costs and subsidy equivalents

A (relatively) simple case: explicit production subsidies for low-emissions products

Measurement is simplest in the case of production of low-emission products such as renewable energy and where it is assumed that:

1. there is an explicit subsidy paid for each unit of production of the low-emissions product

4 For the United States, a comprehensive and consistent measurement of the economic cost effectiveness of a wide range of energy policies has been produced by Resources for the Future and National Energy Policy Institute using a version of the US Energy Information Administration's National Energy Modelling System (NEMS) (Krupnick et al. 2010).

5 The OECD (2010) uses the terminology 'producer support estimates' for these measures in relation to agricultural assistance policies.

2. it is assumed that there would be no production of the low-emissions product without the assistance policy
3. consumers consider the low-emissions product (for example, electricity generated from renewable sources) to be perfectly substitutable for a higher-emissions product (such as electricity generated from coal)
4. the higher-emissions product is produced at constant marginal costs.

In this case, the subsidy equivalent from government — the production subsidy equivalent multiplied by annual production — provides additional revenue to low-emissions producers that is used to pay for the additional resource costs of producing their output[6] and, depending on costs, leaves some producer surplus.

On the basis of the commonly-used approximation that the marginal costs of producing the low-emissions product is linear, the additional resource costs will be greater than one-half of the subsidy equivalent and at most equal to the subsidy equivalent. To split the subsidy equivalent into additional resource costs and producer surplus, the marginal cost of producing low-emissions products is needed[7], but is generally unknown. For this reason, it is necessary to rely on an estimate of the subsidy equivalent as a proxy for the additional resource cost, even though it will generally overstate it.

More complicated cases

In addition to explicit production subsidies (assumption 1) there are a large number of other less transparent policies that assist the production of low-emissions products and thus implicitly subsidise them. In these cases, it is necessary to estimate the production subsidy *equivalents*.

This is straightforward with renewable energy certificate schemes, where the certificate price is equivalent to a production subsidy. And the production subsidy equivalent of a feed-in tariff is the tariff rate less the wholesale price of electricity.

In other cases, estimation of production subsidy equivalents is less straightforward. With input subsidies, for example, it is necessary to convert them to a per unit of output basis to make them equivalent to a production subsidy. Up-front lump sum capital subsidies have to be converted to an annual basis to determine the production subsidy equivalent. With an ETS, the production subsidy equivalent for

6 These resource costs of producing the low-emissions product are those additional to the cost of producing the higher-emission equivalent.

7 This can be seen in boxes 3.1 and 3.2 where the subsidy equivalent is area *befg,* additional resource costs are area *bdfg* and producer surplus is area *def*.

a low-emissions producer is equal to the permit price times the difference between their emissions intensity and that of higher-emissions producers.

If assumption 2 is relaxed — that is, there would have been some production of the low emission product without the policy — the link between the subsidy equivalent and the additional resource costs of the policy becomes less direct. This is because, depending on scheme design, the subsidies may flow to existing production as well as incremental production, while the additional resource costs of the intervention come only from the incremental units. For this reason, it is important that the subsidy equivalent calculations used for cost comparisons across policies and countries only included policy-induced production.

More measurement difficulties arise where high-emissions and low-emissions products are imperfect substitutes (assumption 3 does not hold). For example, biofuels are not perfect replacements for their conventional fuel counterparts. In these cases measurement is difficult because in principle it is necessary to know the supply and demand of the low-emissions product and how these change in response to the policy. In practice, with biofuels it has been assumed that, after adjusting for energy content, they are perfectly substitutable with conventional fuels (chapter 5).

There are further issues if assumption 4 is relaxed and there are increasing marginal costs of producing the high-emissions substitute. This has implications for the breakdown of the low-emissions product's subsidy equivalent into additional resource costs and producer surplus. Nonetheless, it remains the case that (with linear marginal costs) the additional resource costs for low-emissions production will be half or more of its subsidy equivalent.

Measuring price uplifts and consumption costs

Any policy that raises product prices to consumers will reduce their consumption and impose costs on them. However, rather than considering the consumption costs of each individual supply-side policy in a sector, the Commission has estimated the price uplift for all policies combined and then made some illustrative estimates of consumption costs.

The price uplift depends on who pays the subsidy equivalents. Where these are paid for entirely by consumers, the uplift will equal the sum of the subsidy equivalents for the sector divided by post-policy consumption (box 3.3). However, where it is known that the subsidy equivalents were funded by taxpayers, they have been excluded from the price uplift estimates. Where the subsidy equivalents are paid by consumers, the price uplift is estimated using the subsidy equivalent on all

production, not just the subsidy equivalents on policy-induced production (which are used as a proxy for resource costs).

The consumption cost is a measure of the value to consumers of foregone consumption of a good, minus the value of other goods that can be purchased instead.[8] In chapter 4, consumption costs are approximated by taking one half of the product of the change in quantity and price uplift. This commonly-used approximation (based on the demand curve being linear) is best for small price changes. For the larger fuel price changes considered in chapter 5, consumption costs have been calculated assuming a constant elasticity of demand.

It is also important to note that there are also costs if the subsidies are paid by taxpayers and not consumers. Because additional taxes further distort individual decision-making, they reduce efficiency and thus introduce an additional excess burden or welfare cost on the broad economy. However, no estimates have been made of these costs.

Measuring abatement

In addition to measuring the subsidy equivalents of individual policies, it is necessary to calculate the abatement brought about by each policy. The difficulty again is that this requires a counterfactual; namely, how much abatement would have happened in the absence of the policy?

Another issue is that policies aimed at supply-side abatement can also generate demand-side abatement if they raise product prices by reducing the quantity demanded and thus emissions. However, it is more convenient to consider first the supply-side abatement of individual policies, and to introduce later the effects of all the sectoral supply-side policies on the demand for the sector's product and emissions.

Supply-side abatement

A simple case is a policy that encourages production of a low-emissions product that then replaces production of a higher-emissions product. In this case, abatement is the additional quantity of the low-emissions product multiplied by the difference in carbon intensities between the high-emissions and low-emissions products.

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8 In boxes 3.2 and 3.3, the consumer valuation of the foregone consumption is *iklm*, while *ijlm* would be diverted to the consumption of other goods and reflects the valuation of those other goods. This leaves the consumption cost, that is, a net loss, of *jkl*.

Nonetheless, identifying the counterfactual can be complicated where the marginal operator varies depending on the circumstances (for example, peak-load electricity), and this can have a substantial impact on the amount of abatement that might reasonably be attributed to a policy. In the case of electricity generation, it is conceivable that at certain times some types of renewable electricity production replace (relatively low emissions) hydro or gas-fired electricity rather than (relatively high emissions) coal-fired electricity, for example.

It is even more complicated when a number of piecemeal, seemingly independent, policies interact. Here, the unintended consequence can be that the abatement impacts of the policies are not additive. One policy may increase the production of a zero-emissions product such as electricity from solar, but it may act to displace another zero-emissions product such as electricity from wind generation.[9]

Furthermore, it is necessary to measure *net* abatement in cases such as biofuels which, by replacing conventional fuels, reduce emissions, but in their production use fossil fuels, which increases emissions. This necessitates using a life-cycle approach to measuring emissions.

Demand-side abatement

Demand-side abatement is important for policies that push up the price of products that embody emissions. These policies obviously include explicit carbon taxes, ETSs and fuel taxes. In addition, to the extent that subsidies increase the prices to users — and demand elasticities are not zero — this will provide an additional source of abatement and, ideally, should be taken into account. In this study the Commission has used estimates of the elasticities of demand for electricity and transport fuels to make some inferences about the likely short-term abatement that the policy measures might achieve, presuming that all costs are passed through to consumers.

Other measurement issues

The timeframe

Ideally, emissions-reduction policies would be assessed over multiple years. This is because:

9 In these cases, as abatement from one policy goes to zero then abatement costs per tonne of CO_2 for that policy goes to infinity. Nonetheless, the combined abatement and costs from the two policies would be included in the sectoral averages.

- policies are often designed to induce capital investments, such as the building of renewable electricity generation, which can take years to complete and result in abatement over many years
- it is common for policies to be phased in over a period of years, such as an increasingly stringent target for the share of electricity generated from renewable sources.

However, this can add considerable complexity, and so its advantages have had to be weighed against the time constraint on the study. In measuring the costs and abatement of policies, the Commission has adopted a partial equilibrium, comparative static approach that compares, in the latest year for which data are available, a snapshot of the post-policy situation to the counterfactual snapshot of no policy.

This is not to say that longer-term issues cannot be accommodated in the framework. For example, a capital subsidy that encourages investment in low-emissions generation, has a one-off upfront cost, but may contribute to abatement over many years. To account for this divergence in costs and benefits, the value of the subsidy can be amortised over the life of the project and expressed on an annualised basis. This can also be done for previous years' capital subsidies, as some of these previous up-front payments also contribute costs today when considered on an annualised basis. Similarly, the costs of policy measures that bring forward investment that might reasonably be assumed to have occurred in the future can be approximated in similar ways by use of appropriate discount rates (chapter 4).

'Additionality'

Some policies promote other domestic objectives (such as revenue raising or reducing local pollution), while having the 'by-product' effect of achieving emissions reductions. (This issue is more likely to arise for policies that are not explicitly intended to target greenhouse gas emissions, such as fuel excise.) Where such policies deliver domestic benefits and would have been undertaken regardless of their impact on greenhouse gas emissions, the marginal costs of any associated abatement will be negligible. Given that policies can have multiple objectives and that it in most cases it is not possible to decompose abatement estimates (or for that matter costs), it is arguable how much can or should be attributed to abatement objectives.

Sensitivity analysis

Given the measurement challenges just outlined, it is inevitable that there will be a degree of uncertainty associated with estimating abatement costs. The Commission has accordingly produced a range of estimates, rather than a single number, for different policies and for each sector in each country. This involved sensitivity analysis, with key assumptions varied within plausible ranges.

3.3 Adding it up

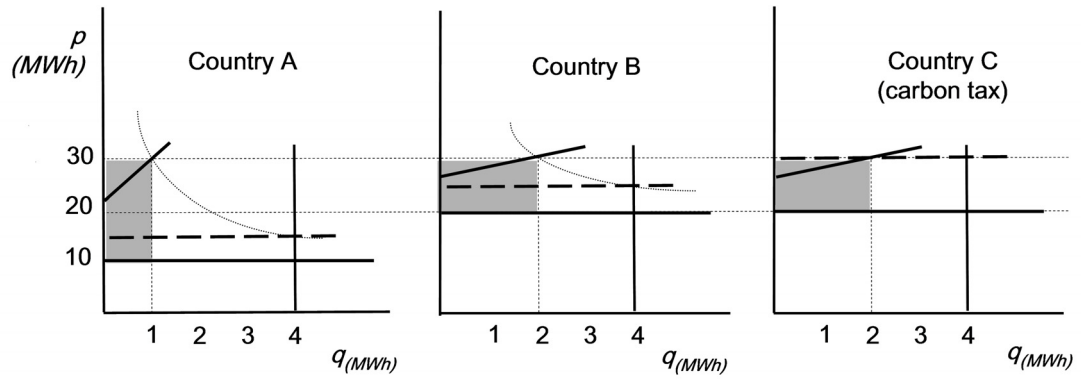
Ideally, the full economic costs and abatement of the various interventions in the study countries would be measured. Given the measurement challenges, for each policy measure, a subsidy equivalent (as a proxy measure of resource costs), and where possible, an implicit abatement subsidy (cost per tonne of CO_2 abated) have been reported. Implicit abatement subsidies could not be estimated for every measure, because,, as noted earlier, in some cases it has not been possible to isolate the abatement effects of individual policies.

Although these proxy measures will typically overstate resource costs, to the extent that they do so consistently across countries, they provide some basis for comparing the *cost effectiveness* of different measures within and across countries in these sectors. They will also be useful indicators of the resources that respective governments are prepared to devote to encouraging abatement, either directly through explicit financial subsidies or indirectly through higher prices paid by consumers.

As far as possible, the Commission has also endeavoured to estimate the overall product price increase or 'uplift' that results from the various interventions in each sector for each country. This information has been used to make some inferences about consumption costs and demand-side abatement. It has been done only after aggregating the subsidy equivalents for each sector. But given the large degree of uncertainty about demand elasticities, estimates of consumption costs can only be illustrative.

The Commission's approach to estimating the sectoral price uplift resulting from the various policies is essentially the same as that followed by Vivid Economics (2010) in a report it undertook for the Climate Institute. Vivid Economics weighted its estimates of the costs of each policy by the share of electricity generation to which that policy applied, to give the price uplift (box 3.6). Vivid Economics referred to this as the sectoral 'implicit carbon price' by expressing it per tonne of CO_2.

Box 3.6 **Issues in 'implicit carbon prices'**



In its report for the Climate Institute, Vivid Economics calculated the cost of abatement for each policy measure, weighted these results by the proportion of electricity generation to which that measure applied, and then summed them. The result was termed the 'implicit carbon price' for that country's electricity-generation sector.

This weighting system is appropriate for calculating electricity price uplifts (when all costs are passed on to consumers). However, it will give a different result for countries that are identical in abatement and costs, but which differ in their cost and emissions intensity of baseload electricity. The result also depends on whether the assistance provided to renewable generators comes via direct intervention or by imposition of a carbon tax or ETS.

Take three countries, each of which devotes the same amount of resources (as proxied by the total subsidy equivalent, and shown as the shaded area in each diagram above) to supporting renewable generators. In country A the quantum of assistance provides one unit of renewable electricity, and in country B it provides two units. This is because in country A, baseload is half the cost in country B, and twice as much subsidy is required to induce the renewable technology supported by country A's intervention. (To simplify the figure, country A and B are assumed to target different technologies hence the different cost functions, but this does not affect the outcome.)

If baseload electricity in country A is assumed to be twice as emissions-intensive as in country B (2 t CO_2/MWh compared with 1 t CO_2/MWh), each country achieves the same amount of abatement at the same additional cost (and hence would have the same implicit abatement subsidy). But Vivid Economics' weighting would mean that country A's assistance would be weighted by a factor of 0.25 (one unit of renewable electricity in four units in total) and country B's would be weighted by 0.5. In other words the 'implicit price of carbon' in country B would be twice that of country A, despite both having the same amount of abatement and the same cost of abatement per tonne of CO_2.

(Continued next page)

Box 3.6 (continued)

Now let country C (which has the same characteristics as country B) impose a carbon tax instead of a technology-specific regulation or subsidy. In this example, the carbon tax provides the same uplift in the prices received by renewable generators, and the same total subsidy equivalent. But because the Vivid Economics approach gave the carbon tax (for its estimate of the United Kingdom) a weighting of 1.0, it contributes more again to the implicit price.

In summary, the abatement subsidy is \$10/t CO_2 for all three countries and they all achieve the same abatement, but the implicit prices that would be derived from the Vivid Economics' approach are \$2.50, \$5.00 and \$10.00/t CO_2 for countries A, B and C respectively.

This is a highly stylised example that uses large hypothetical differences in emissions intensity and cost, but it serves to illustrate some of the issues in interpreting a single measure of costs that is weighted by shares of generation.

These three scenarios can also be used to illustrate what would happen to electricity prices if the full amount of the tax equivalent was passed through to customers. The tax equivalent for countries A and B is equal to the subsidy equivalent, but in country C the total tax equivalent equals the full revenue from the carbon tax, some of which accrues to renewable generators as a subsidy and some to government. For both country A and country B the price uplift would be \$5/MWh, but because of the different cost base this would represent a 50 per cent increase in country A and a 25 per cent increase in country B. Full pass-through of the carbon tax in the case of country C would result in a \$10/MWh rise in electricity prices, a 50 per cent increase. Thus, in this example, country A with the lowest 'implicit carbon price' has the (equal) highest percentage increase in electricity prices.

This example also illustrates that the Vivid Economics 'implicit carbon price' can be interpreted as (and is equivalent to) the price uplift per MWh divided by the baseload emissions intensity. That is, dividing the price uplift for each country (\$5, \$5 and \$10/MWh for A, B and C respectively) by their emissions intensity (2.0, 1.0 and 1.0 t CO_2/ MWh) gives the country's 'implicit carbon price' (\$2.50, \$5 and \$10/ t CO_2). Thus, all else the same, the higher the emissions intensity, the lower the 'implicit carbon price'.

To demonstrate this, the Commission has calculated from Vivid Economics' published figures that their average abatement subsidies for Australia and the United States would be US\$15.27 and US\$15.38/t CO_2, respectively. Using Vivid Economics weighting, these translate into electricity price uplifts in the two countries of US\$2.45 and US\$4.80/MWh. Based on emissions intensities for the two countries (1.05 and 0.95), their 'implicit carbon prices' are US\$2.34/t CO_2 and US\$5.05/t CO_2.

Finally it is important to note that these 'implicit carbon prices' cannot be compared to *explicit* carbon prices of the same value. In the above example as drawn if country B converted its 'implicit carbon price' of \$5 into an explicit carbon tax of \$5, it would achieve no abatement and have no abatement costs (with demand unresponsive to price) while raising \$20 in revenue.

The Commission's estimates of price uplift are expressed per unit of output and comparisons are made across countries of the percentage increase in output prices as a result of the emissions-reduction policies examined. While these price uplifts are one important metric in cross-country comparisons of the effects of carbon policies, it is necessary also to compare abatement achieved and the economic costs incurred. Countries could have similar abatement and costs with different price uplifts or vice versa (box 3.6).

It is also important to note that the estimated price uplift is not a *carbon price* equivalent. That is, the imposition of an economy-wide carbon price that would result in the same price uplift would not achieve the same abatement as the existing sectoral policies, nor would it have the same costs of abatement.

Conceptually, there are a number of different economy-wide carbon prices that are equivalent to existing sectoral policies in a *single* aspect of their impacts but not others (box 3.7). The imposition of an economy-wide carbon price that would result in the same amount of abatement as existing policies would not involve the same cost nor would it achieve the same price uplift. Or the imposition of an economy-wide carbon price that imposed the same costs as existing policies would not result in the same abatement. In other words, there is no single economy-wide carbon price that would bring about precisely the same level, type and cost of abatement as a scheme that assists a narrow subset of abatement options.

Box 3.7 **The elusive 'implicit' carbon price equivalent of a subsidy**

There are a number of different carbon price equivalents that could capture a particular aspect of the impacts of a subsidy scheme.

First, it would be possible to estimate the carbon price or tax that would deliver the *same average increase in electricity prices* as a renewables subsidy (assuming that the subsidy is paid for by electricity consumers rather than taxpayers). But this carbon price would be too low to support the level of renewable production that the subsidy brings forth and, indeed, too low to generate much abatement from any other low-emissions technology. Moreover, for any given abatement cost, this particular carbon price will be lower, the greater the emissions intensity of baseload generation.

Second, there will generally be a carbon price level or rate of tax capable of inducing the *same amount of renewable energy* as a renewables subsidy. Indeed, that carbon price or tax would need to equal the (explicit or implicit) unit subsidy. But unlike the subsidy scheme, this level of carbon price or tax would also lead to additional abatement by increasing consumer prices and reducing consumption of electricity overall, and by encouraging other production technologies (for example, gas-fired generation). (And the broader the base of the carbon price or tax, the greater the abatement for any given price.)

Third, there will be a carbon price or tax that would generate the *same costs* as the subsidy scheme, but this carbon price will be lower than the unit subsidy and would also likely generate greater abatement from different sources to the subsidy scheme (again depending on the coverage of the carbon price scheme).

A fourth approach would be to calculate the carbon price or tax that would deliver that *same total amount of abatement* as the renewables subsidy, from the most efficient (lowest-cost) sources. While this would be equivalent to the subsidy in that particular respect, the resulting abatement would not come from the same sources or occur at the same cost. That said, such a calculation would usefully highlight to governments the relative cost effectiveness of the mitigation policies they have in place. (But these 'efficient' carbon price equivalents, assuming they could be estimated for each country, would still provide little guidance as to whether countries should undertake more or less abatement.)

4 The electricity generation sector

Key points

- The Commission estimated the total subsidy equivalent and the abatement attributable to a subset of policies that are having the greatest impact in the study countries. The estimates give an indication of the resources the countries are devoting to emissions reductions, the level of abatement that policies are achieving, and their cost effectiveness.
- When expressed as a proportion of counterfactual electricity-sector greenhouse gas emissions, the total abatement from the policies analysed is estimated to be highest for Germany, followed by the United Kingdom, Australia, the United States, China, Japan and South Korea.
- Likewise, when total subsidy equivalent estimates are expressed as a proportion of GDP, the estimate is highest for Germany, followed by the United Kingdom, Australia, China, South Korea, the United States and Japan.
- The estimated implicit abatement subsidies — which give an indication of the cost per tonne of abatement in each country — were highest for South Korea, followed by Japan, Germany, the United Kingdom, Australia, the United States, China and New Zealand.
- Implicit abatement subsidy estimates can be used to compare the relative costs of different approaches to reducing emissions:
  - The European Union Emissions Trading Scheme delivers significant abatement in the United Kingdom at a relatively low resource cost.
  - Policies that encourage large-scale renewable energy projects were found to be the next least costly, but impose higher costs where some policy instruments are used.
  - Subsidies for solar photovoltaic systems were consistently found to have been the most costly way of achieving abatement for all countries.
  - The Chinese Government's policy of shutting down small coal-fired power plants and replacing them with more efficient plants, appears to have been cost-effective in its own right, because the savings in operating costs from using more efficient technologies outweigh the costs of new plant.
- Illustrative calculations, based on various simplifying assumptions, suggest that the analysed policies have induced little demand-side abatement in percentage terms, except in Germany and the United Kingdom.

This chapter presents the Commission's quantitative analysis of abatement and costs of a selection of policies in the electricity generation sector of the study countries. The analysis is restricted to electricity generation — the use of fuel (fossil, nuclear or renewable) to create electrical energy. Electricity transmission, distribution and retail are not included in the analysis. The first section describes the types of policies that were assessed and the approach taken. Section 4.2 sets out comparisons of the estimates for the supply side of the electricity generation sectors in the study countries. Section 4.3 sets out the supply-side results for each country. Section 4.4 contains illustrative estimates of the effects of the policies on electricity prices and demand-side abatement.

4.1 Reducing emissions from electricity generation

The terms of reference requested the Commission to 'estimate the effective carbon price per tonne of CO_2-e faced by the electricity generation sectors' in the study countries. For the reasons set out in chapter 3, the Commission's approach was to estimate the total subsidy equivalent for a range of policies in each country, and the abatement (from the supply side and demand side) attributable to these policies.

The scope of the quantitative analysis

Governments use a range of policy instruments to reduce emissions from electricity generation — well over 100 policies were identified in the policy stocktakes for the study countries (available on the Commission's website). Quantitative analysis was restricted to a subset of policies that:

- act directly on electricity generation
- penalise emissions or provide an incentive for lower-emissions generation
- have a material effect on electricity-sector emissions and/or involve significant resource costs for the study countries.

In general, the analysis covered the policies that were having the most material effects in each country in the relevant period. However, time and data constraints meant that some policies that could have met these criteria were not included in the quantitative analysis. In addition, numerous smaller policies that were not included in the analysis could, in combination, have material effects (this is potentially significant for the United States). Where the exclusion of policies may have had a material effect, this is noted in the relevant section. In general, the omission of policies from the analysis is likely to have led to underestimates of subsidy equivalents rather than of abatement.

The policies that were analysed fit into three broad categories:

- *Production subsidies* operate by paying a subsidy to lower-emissions generators for each unit of electricity they supply into the grid. Commonly-used instruments include renewable energy certificates (RECs), feed-in tariffs (FITs), and production tax credits (chapter 2).
- *Capital subsidies* are transfers that subsidise the capital costs of investment in low-emissions generators. Instruments include direct cash transfers, investment tax credits, government-provided loans, and loan guarantees.
- *Emissions trading schemes* (ETSs) change the marginal costs of electricity generation — the more emissions-intensive the technology, the greater the increase in its marginal cost. Depending on the price of emissions permits, this can make low-emissions electricity less costly than higher-emissions electricity, and increase the market share of gas and renewables.

All study countries have a similar suite of regulatory policies directed at improving the energy efficiency of products and buildings using electricity. These include:

- compulsory energy efficiency labelling and minimum performance standards for a range of household appliances and some commercial and industrial machinery
- mandatory energy efficiency standards for new residential and commercial buildings and major renovations to existing buildings
- requirements for government agencies to increase the energy efficiency of their operations
- mandatory energy audits and reporting for large energy users
- direct financial assistance to consumers and businesses to encourage the purchase of more energy efficient appliances and machinery and the improvement of energy efficiency in buildings
- requirements for electricity providers to subsidise energy efficiency improvements by their customers or the wider community.

A number of these policies are outlined in more detail in chapter 2 and appendix C. The policy stocktakes on the Commission's website provide a more complete listing of the energy efficiency policies implemented in individual study countries.

Energy efficiency policies will generally reduce the demand for electricity and lead to lower greenhouse gas emissions. However, as outlined in chapter 3, their effects — and particularly their costs — are very uncertain and hence are not estimated here (appendix C discusses these issues in some detail). However, while the breadth and diversity of policies across countries makes comparisons difficult, Australia

generally has a similar mix and stringency of energy efficiency regulations for electricity usage to those in most other study countries.

In addition, as previously discussed, research and development policies were not included in the quantitative analysis, because of their uncertain effects and the fact that outlays in one year are unlikely to have much impact in the same year of analysis.

What the Commission has estimated

The policies chosen for the quantitative analysis all provide a subsidy (explicit or implicit) for electricity generation from lower-emissions sources (generally renewables or gas). The Commission estimated how much these policies reduced emissions in the most recent year for which data were available (generally 2009 or 2010), the costs of the abatement and the cost effectiveness of policy instruments and technologies.

Detailed descriptions of the methodological approaches and data are set out in appendixes D–L (available on the Commission's website). The estimates were based on publicly-available information, and information provided by the governments of the study countries and by contractors. Governments were given the opportunity to comment on drafts of the appendixes that related specifically to their countries.

Estimating subsidy equivalents

For each policy, the Commission estimated a subsidy equivalent. This measures the outlays required to 'buy' certain amounts of abatement from particular sources. A subsidy equivalent is also an upper-bound proxy for resource costs; that is, the economic costs of the policies designed to promote lower-emissions generation. The subsidy equivalent was estimated in different ways for each policy instrument (details are set out in appendixes D–K).

Where several policies provide subsidies for the same unit of renewable generation, the subsidy equivalent estimate for each policy was included in the analysis.

It should be noted that for some policies, only a portion of the total outlay was counted toward the subsidy equivalent. This is the case where policies provide a subsidy to generation that would have occurred in the absence of any policy intervention (such as a subsidy to pre-existing hydroelectricity under some REC schemes). This portion of the subsidy is essentially a transfer and does not

contribute to the resource costs of the policy, although such payments will involve real economic costs being imposed on consumers or taxpayers, depending on who has to pay. (Hence, transfers are counted in the analysis of electricity price uplifts.)

To account for these transfers, the Commission estimated how much additional generation can be credited to each policy through an assessment of the policy design and changes in the use of low-emissions generation since the introduction of the policy.

Estimates of the subsidy equivalents for the various policies were added to derive an estimate of the total subsidy equivalent for each country.

Estimating abatement

The Commission also estimated the abatement attributable to the set of policies that were analysed for each study country. In many cases, policy overlaps meant that it was not possible to attribute abatement to individual policies. Instead, to avoid double counting, in many cases the Commission estimated the abatement that arose in each country through different technologies (for example wind or solar power).

Abatement was estimated against a counterfactual of no policy intervention. That is, what would greenhouse gas emissions have been if the policy were not in place? To do this, it was necessary to identify the source of electricity that would have been used in the absence of the subsidised low-emissions generator. Abatement is reported in tonnes of CO_2 (t CO_2), rather than tonnes of CO_2 equivalent (CO_2-e), because in most cases the available estimates of greenhouse gas emissions from electricity generation only included CO_2. Other gases (such as methane and nitrogen oxides) were not included. However, CO_2 generally accounts for 98 per cent of greenhouse gas emissions from fossil fuel combustion (or higher), so excluding these gases is not likely to have had material effects on the overall results.

Implicit abatement subsidies

The estimated implicit abatement subsidy for a policy, technology or the electricity generation sector of a country as a whole is calculated by dividing the subsidy equivalent by the abatement induced. This gives an indication of the cost effectiveness of the abatement options being pursued. (The higher the implicit abatement subsidy, the less cost-effective a measure or set of measures is likely to be.)

Demand-side effects

The Commission estimated the effects of the policies on electricity prices, consumption costs and greenhouse gas emissions in the study countries (section 4.4). These estimates are assumption-driven and should be regarded as illustrative.

Sensitivity analysis

Estimates of subsidy equivalents and abatement attributable to policies were based on assumptions about the characteristics of the electricity generation sectors in the study countries, the cost of capital and some other variables. Where such assumptions played an important role, estimates were subjected to sensitivity analysis — systematically varying parameter values to demonstrate the effects of changes. The results are reported in a range that reflects the sensitivity analysis.

4.2 Subsidy equivalents and abatement compared

This section presents the results for the supply side of the electricity generation sector, including international comparisons of abatement and total subsidy equivalents, comparisons of the cost effectiveness of various technologies, and detail on the results for each study country.

Comparing abatement across countries

For each study country, abatement was estimated for the set of policies that were analysed. While the analysis was restricted to a subset of the emissions-reduction policies in each country, for most countries those that were assessed are likely to have captured the majority of the subsidised low-emissions generation. Analysing additional policies in most countries would not be expected to lead to significantly higher estimates of total electricity sector abatement in the years of analysis.

Differences in the characteristics of the study countries mean that estimates of total abatement are not directly comparable in absolute terms. One reason is the size of the countries — in proportionate terms one tonne of abatement represents less ‘effort’ for a large country than for a small one. A second issue is that each of the study countries has different natural resource endowments and patterns of energy use. This means that achieving a given amount of abatement requires different levels of effort for each country. For example, if all countries applied the same policy measure (such as a production subsidy of A$50 per megawatt hour (MWh)

for wind power), the abatement from that policy would be expected to differ among countries.

One way to make cross-country comparisons more meaningful is to scale the estimates according to what the country's total electricity-sector greenhouse gas emissions would have been in the absence of the policies (table 4.1, figure 4.1). The results show that, relative to total electricity-sector emissions, the policies that were analysed for Australia were estimated to have led to less abatement than in the United Kingdom and Germany, and more abatement than the policies analysed for South Korea, Japan, China and the United States.

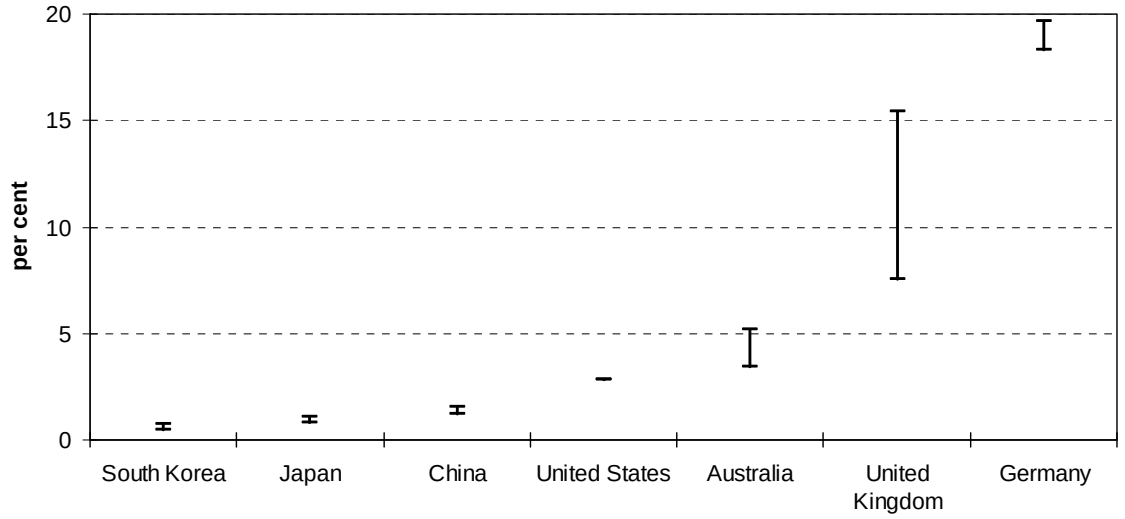
Table 4.1 **Estimates of policy-induced abatement**

Country	*Total electricity sector emissions*	*Estimated abatement*	*Abatement as a percentage of counterfactual electricity-sector emissions*[a]
	Mt CO_2	Mt CO_2	%
Australia	196	7–11	3–5
China[b]	3 370[c]	41–52	1–2
United States	2 270	67	3
United Kingdom	151[d]	12–27	8–15
Germany	299[d]	67–73	18–20
Japan	396[e]	3–4	<1
South Korea	191[e]	1	<1

[a] Counterfactual emissions are calculated as the sum of actual electricity-sector emissions and estimated abatement. [b] Results for China do not include the 'Large Substitute for Small' program. [c] Productivity Commission estimate of China's electricity-sector emissions in 2010. [d] 2009 data. [e] 2008 data.

Sources: Appendixes D–K.

Figure 4.1 **Abatement as a proportion of counterfactual electricity sector emissions[a]**



a Lines show the Commission's lower and upper-bound estimates of electricity generation sector abatement for each country. Results for China do not include the 'Large Substitute for Small' program.

Source: Productivity Commission estimates.

Comparing total subsidy equivalents across countries

The estimates of the subsidy equivalents of each policy were added to derive a total subsidy equivalent for each country. This shows the outlays that countries are making to 'buy' abatement. As with the estimates of abatement, estimates of total subsidy equivalents are more meaningful when put into context, reflecting the characteristics of the study countries. For this reason, the estimates are reported in dollar values, and as a proportion of GDP (table 4.2, figure 4.2).

The results suggest that, as a proportion of GDP, the estimated total subsidy equivalent for electricity sector policies in Australia is somewhat larger than for the policies that were analysed for Japan, the United States, South Korea and China, and significantly less than for the United Kingdom and Germany.

In interpreting these estimates, it should be noted that some of the policies that were not included in the analysis could have had a material effect. In particular, for the United States, the analysis included two large federal-level programs and 13 state-level programs. However, there are numerous state-level programs that were not included in the analysis because of time and data constraints. It is likely that some of these policies provide material subsidies to low-emissions generators.

Excluding these policies from the analysis will underestimate the total subsidy equivalent.

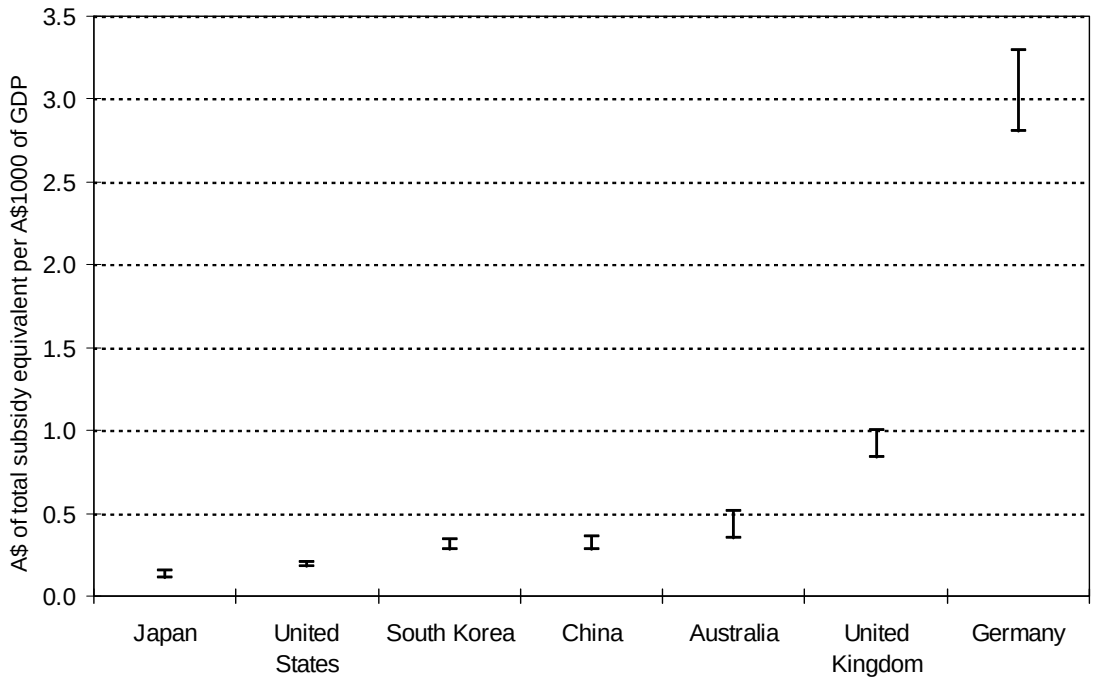
Table 4.2 **Estimates of total subsidy equivalents**

Country	*GDP*	*Total subsidy equivalent*	*Total subsidy equivalent as a percentage of GDP*
	A$b (2010)	A$m (2010)	% GDP
Australia	1 343	473–694	0.04–0.05
China	6 402[a]	1 835–2 309	0.03–0.04
United States	15 936	2 886–3 339	0.02
United Kingdom	2 437	2 042–2 433	0.08–0.10
Germany	3 572	10 019–11 947	0.28–0.33
Japan	5 959	669–940	0.01–0.02
South Korea	1 101	313–379	0.03

[a] GDP figure for China does not include Hong Kong.

Source: Appendixes D–K.

Figure 4.2 **Total subsidy equivalents as a proportion of GDP[a]**



[a] Lines show the Commission's lower and upper-bound estimates of electricity generation sector total subsidy equivalents for each study country.

Source: Productivity Commission estimates.

Comparing implicit abatement subsidies across countries

The implicit abatement subsidy for each country's electricity generation sector is the total subsidy equivalent divided by total abatement. The results are reported in A$/t CO_2, and can be interpreted as an upper-bound estimate of the average resource costs of a tonne of abatement. The implicit abatement subsidy is not a 'carbon price'. Rather, as noted in chapter 3, it gives an indication of the cost effectiveness of the set of policies that were analysed for each country in achieving abatement.

Two factors have a particularly significant influence on the implicit abatement subsidy estimates. The first is the emissions intensity of each country's electricity generation sector. Specifically, for a given total subsidy equivalent, the implicit abatement subsidy will be lower in countries where renewable energy sources displace emissions-intensive sources. For example, a given total subsidy equivalent to renewable energy in a country where renewables displace coal will yield a lower implicit abatement subsidy than the same total subsidy equivalent in a country where renewables displace gas, other things being the same.

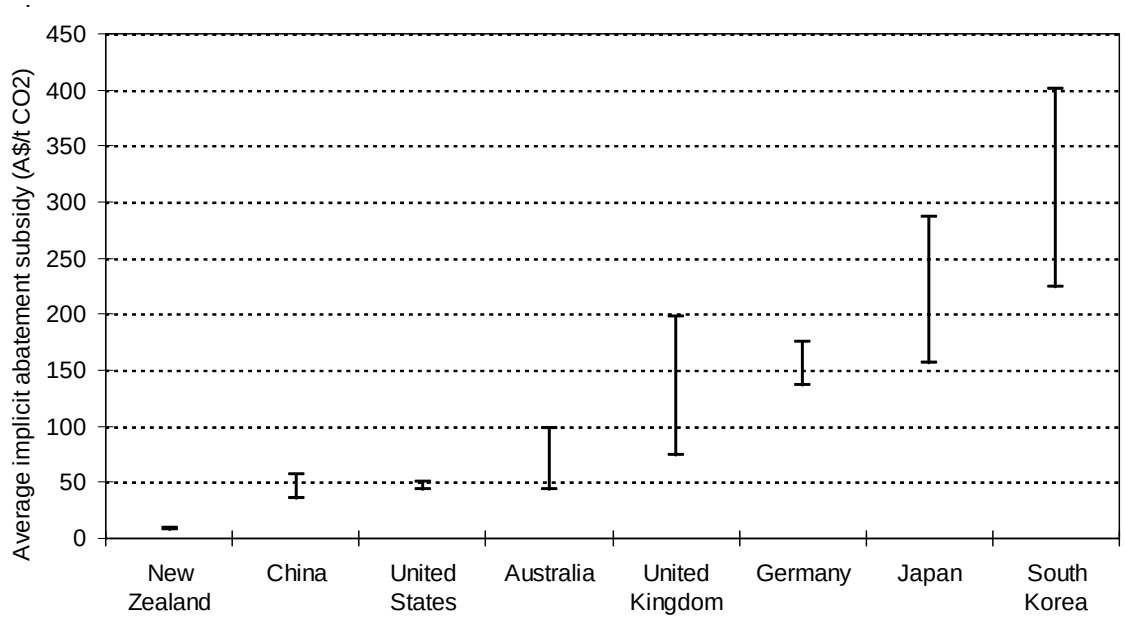
A second relevant factor is the rate of the production subsidy provided to renewables. The higher the production subsidy (expressed in A$/MWh), the higher the implicit abatement subsidy, other things being equal. Production subsidy rates tend to be related to the costs of technologies, and reflect decisions to favour particular technologies.

Bearing in mind the difficulties in making cross-country comparisons, it is reasonable to draw the following conclusions from the results (figure 4.3):

- The lowest implicit abatement subsidy estimate internationally is for New Zealand, for which only one electricity sector policy was analysed — the recently-introduced New Zealand ETS.
- Despite their participation in the European Union ETS, the estimated implicit abatement subsidies for Germany and the United Kingdom are relatively high because of the generous subsidies that the two countries provide to renewables.
- Policies analysed in Japan and South Korea achieved relatively low levels of abatement, but at a relatively high cost (mainly because of large production subsidies paid to high-cost solar photovoltaic (PV)).
- The implicit abatement subsidy range estimated for Australia (A$44–98) is lower than for some countries, but high relative to the New Zealand and European Union Emissions Trading Schemes (discussed further below).

For reasons set out in the section on subsidy equivalent estimates, the implicit abatement subsidy for the United States should be regarded as a lower-bound estimate.

Figure 4.3 **Implicit abatement subsidies[a]**



a Lines show the Commission's lower and upper-bound estimates of electricity generation sector implicit abatement subsidies for each country.

Source: Productivity Commission estimates.

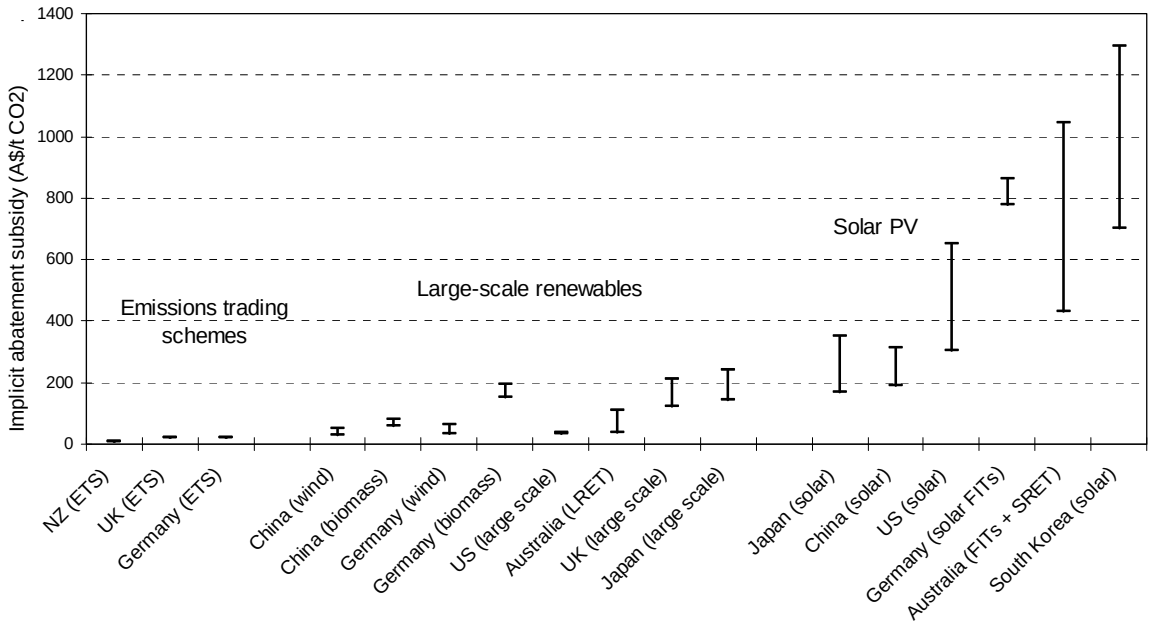
Comparing emissions-reduction technologies

In some cases, it was possible to estimate the implicit abatement subsidies associated with individual policies. Where these policies support a particular technology, the results can be used to compare the cost effectiveness of using different technologies to achieve emissions reductions (figure 4.4). The results support some significant conclusions.

First, emissions trading schemes are found to have been the most cost-effective instruments identified. The European Union ETS appears to be leading to abatement by encouraging a switch from coal to gas. The effects are more pronounced in the United Kingdom than in Germany, because Germany had less surplus gas-fired generation capacity in the year of analysis. Sources of abatement under the New Zealand ETS are not yet clear, because the scheme has only applied to electricity generation since 2010, and current transition arrangements mean that the scheme

has probably not yet had a significant effect on the day-to-day production decisions of New Zealand electricity generators. Moreover, around three-quarters of electricity generation in New Zealand is already from renewables (mainly hydroelectricity, geothermal and wind power), with most of the remainder coming from gas. This suggests that there are limited opportunities for New Zealand to further reduce the emissions intensity of its electricity generation sector, compared to other countries that rely more heavily on fossil fuels.

Figure 4.4 **Implicit abatement subsidies — technologies and policies[a,b]**



a Lines show the Commission's lower and upper-bound estimates of electricity generation sector implicit abatement subsidies for each country, broken down by technology. Only a subset of the policies could be broken down by technology. Where a data point is labelled 'large scale', the policy applies to numerous large-scale renewable technologies, and the effects could not be disaggregated any further. In most cases, the majority of large-scale renewables are wind and biomass. **b** For Australia, 'LRET' refers to the large-scale component of the Renewable Energy Target. 'SRET' refers to the small-scale component. Both components were analysed for 2010.

Source: Productivity Commission estimates.

A second clear finding is that solar PV is currently a relatively costly abatement option. Solar PV is a high-cost technology (box 4.1), and hence subsidy rates for solar PV need to be high to make it competitive at prevailing market prices. Furthermore, subsidy rates for solar PV often have been set at excessive levels, essentially providing windfall benefits to households that install solar PV. In Australia in 2010, the combined effect of the Renewable Energy Target and state and territory FITs was estimated to have provided a subsidy equivalent to solar PV of A$149–194 million. Abatement from solar PV through these policies was

estimated to be 0.2–0.3 Mt CO_2, which implies implicit abatement subsidies for solar PV of A$432–1043/t CO_2 — some of the highest identified in this study.

Box 4.1 **The costs of electricity sources**

The levelised cost of electricity (LCOE) is a widely-used measure of the cost of electricity generation technologies. Estimates of the LCOE are sensitive to assumptions about factors such as capital costs, the useful life of assets and the technical efficiency of generation technologies. As such, they should be treated as an indicative guide to the relative costs of various technologies.

The Electric Power Research Institute (2010) reported estimates of the LCOE of various sources of electricity in Australia, including:

- coal-fired electricity (without carbon capture and storage) — A$78–91/MWh
- combined-cycle gas turbines (without carbon capture and storage) — A$97/MWh
- wind — A$150–214/MWh
- medium-sized (five megawatt) solar PV systems — A$400–473/MWh.

Smaller domestic PV systems are likely to have higher costs again. The high LCOE for solar PV is one of the reasons that policies that subsidise solar PV have high implicit abatement subsidies.

Source: Electric Power Research Institute (2010).

The results for large-scale renewables are less clear. The implicit abatement subsidies are higher than for ETS-induced coal-gas switching, and generally lower than for solar PV. However, there is significant variation in the implicit abatement subsidy estimates. Some of this is accounted for by differences in the costs of renewables in the study countries. Another factor is the different instruments used to subsidise renewables. The two most common are renewable energy certificate (REC) schemes and feed-in tariffs (FITs).

REC schemes work by setting an overall target for the use of renewables. Under a REC scheme, all renewables receive the same subsidy per MWh, and the market determines the mix of renewables that will meet the target at the lowest cost. FITs operate by setting a guaranteed payment for electricity from renewable energy sources that is fed into the electricity transmission grid. FITs are generally set at different rates for different technologies. Inevitably, FIT rates are set at higher levels than would be necessary to induce the least-cost mix of renewables, and the overall resource cost of using a particular level of renewables will be higher than under a REC scheme.

4.3 Results for each country

The following sections set out the results for each country that have been drawn on above. Key drivers of abatement, total subsidy equivalents and implicit abatement subsidies for each country are explained, and significant policies are described in greater detail. Full explanations of how subsidy equivalents and abatement were estimated for each policy are provided in appendixes D–K (available on the Commission's website).

Australia

A large number of emissions-reduction measures apply to Australia's electricity generation sector. The quantitative analysis was restricted to a subset of measures that were considered likely to have had a material effect on the total subsidy equivalent and/or total abatement estimates in 2009 or 2010 (the years of analysis). Specifically, the analysis included:

- the large and small-scale components of the Renewable Energy Target (RET)
- state and territory solar PV FITs
- the NSW and ACT Greenhouse Gas Reduction Scheme (GGAS)
- the Queensland Gas Scheme.

It should be emphasised that the estimate of the abatement attributable to the Queensland Gas scheme is an upper-bound estimate. It is likely that some of the gas generation that has been subsidised by the scheme would have been in service even without the incentives provided under the scheme.

A number of federal, state and territory capital subsidy programs (such as the Solar Flagship program, various Solar Schools programs, the Victorian Large Scale Solar Project, and the Low Emissions Energy Development Fund) were not included in the analysis as they were not considered likely to have led to material abatement or to have had significant resource costs in 2010.

In proportionate terms, Australia's total abatement and total subsidy equivalent were the third highest of the study countries (behind only Germany and the United Kingdom) (table 4.3). The average implicit abatement subsidy is lower than for South Korea, Japan, Germany and the United Kingdom, and higher than for the United States, China and New Zealand.

Table 4.3 **Effects of emissions-reduction policies, Australia**
2009, 2010

Policy name	*Policy type*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
		A$m (2010)	Mt CO_2	A$/t CO_2
Renewable Energy Target	REC scheme	335–556	4.3–8.0	42–129
Large-scale component		283–459	4.1–7.6	37–111
Small-scale component		52–98	0.2–0.3	152–525
State and territory solar feed-in tariffs	FITs	96	–[a]	..
New South Wales		43	–[a]	..
Victoria		22	–[a]	..
Queensland		21	–[a]	..
Western Australia		2	–[a]	..
South Australia		6	–[a]	..
ACT		2	–[a]	..
GGAS (New South Wales and ACT)	Emissions offsets scheme	3	0.6	5
Queensland Gas Scheme	Target for gas-fired electricity	38	2.1[b]	18
Total for solar PV[c]		149–194	0.2–0.3	431–1 043
Total		**473–694**	**7–11**	**44–99**

[a] No abatement is attributed to the state and territory solar FITs, because in 2010 the schemes overlapped fully with the RET (box 4.2). [b] Abatement estimates for the Queensland Gas Scheme should be treated as an upper bound, as they probably include some gas-fired generation that would have been brought into service even if the scheme was not in place (appendix D). [c] Combined effects of the small-scale component of the RET and the state and territory FITs. **–** Nil or rounded to zero. **..** Not applicable.

Source: Appendix D.

A key finding from the analysis is that subsidising the installation of small-scale solar PV systems significantly increases the average implicit abatement subsidy and hence the resource costs of abatement. The implicit abatement subsidy for the programs that subsidise solar PV (the small-scale component of the RET and the state and territory FITs) was estimated to be in the range of A$431/t CO_2–A$1043/t CO_2. If these policies did not exist, it is likely that there would have been much less small-scale solar PV installed, and the electricity sector average implicit subsidy would have been around 25–30 per cent lower (A$31–73/t CO_2 rather than A$44–99/t CO_2). Furthermore, because the state and territory FITs overlapped completely with the RET in 2010, they did not lead to any additional abatement, and only added to the total financial costs of meeting the target (box 4.2). In fact, due to a peculiar effect of the RET scheme in 2010, the

FITs could have actually led to higher emissions than if there had been no FIT schemes.

Subsidies for large-scale renewables under the RET were responsible for more than half of the estimated abatement. The large-scale component of the RET was less costly than subsidies for solar PV, but its implicit abatement subsidy was still high relative to more cost-effective policies (such as the European Union ETS).

It is worth noting that the Commission's implicit abatement subsidy estimates for individual policies are broadly comparable to estimates by others of the costs of abatement of the policies (box 4.3).

Box 4.2 State and territory solar FITs — high cost and minimal abatement

All states and territories in Australia offer FITs for solar PV. In 2010, the state and territory FITs overlapped completely with the national RET, as each MWh of electricity subsidised through FITs in 2010 was also eligible for subsidies under the RET. Given that the RET set a binding target for the use of renewables, each MWh of solar electricity simply offset abatement from other renewable sources, and hence the FITs did not lead to any additional abatement.

In fact, the Commission's analysis found that if the state and territory FITs increased the installation of solar PV systems, the result could have been a net increase in emissions in 2010. The reason is that owners of solar PV were granted five RECs for every MWh of electricity generated. Therefore, each 'solar-generated REC' was equivalent to only 0.2 MWh of renewable electricity. Other renewable generators received only one REC per MWh. Hence, each 'solar-generated REC' that was surrendered in 2010 would have reduced the net generation from renewables by 0.8 MWh, leading to higher total emissions than if the solar PV system had not been installed. This anomaly was addressed through changes to the RET scheme in 2011.

Box 4.3 **Other estimates of the cost of abatement**

The Renewable Energy Target

The Commission's estimate of the implicit abatement subsidy of the large-scale component of the RET (A$37–111/t CO_2) is in a similar range to other published estimates of the cost of the RET, including:

- Grattan Institute (Daley and Edis 2011) — A$30–70/t CO_2 (depending on the certificate price)
- Ministerial Council on Energy (2002) — A$44–73/t CO_2
- Electricity Retailers Association of Australia (ERAA 2005) — A$60–80/t CO_2.

Queensland Gas Scheme

The Grattan Institute estimated that the cost of abatement under the Queensland Gas Scheme has been in the range of A$20–A$40/t CO_2. The Commission's estimate is slightly lower than the lower bound of this estimate. This appears to be due to the lower permit price in 2009.

Greenhouse Gas Reduction Scheme

Estimates of abatement induced by GGAS vary, due to differing assumptions regarding the additionality of the scheme. For example, DCC (2010) reported 'induced' abatement of 4.7 Mt CO_2. This was revised to 0.7 Mt CO_2 in DCCEE (2011e). The Commission's estimate was based on the most recent DCCEE estimate.

Sources: Daley and Edis (2011); DCC (2010); DCCEE (2011e); ERAA (2005); Ministerial Council on Energy (2002).

China

Six measures were analysed. Five provide incentives for renewables in the form of capital subsidies or FITs. The sixth, the 'Large Substitute for Small' (LSS) program, targets the efficiency of China's coal-fired electricity generation.

A number of policies were not included in the analysis, as research suggested that they were not likely to have been material relative to the policies that were analysed (appendix E). However, some other policies that were excluded from the analysis on data grounds may have material effects. Overall, it is likely that the policies that were analysed capture a large proportion of the types of measures being pursued in China's electricity generation sector in 2010, the subsidies they provided to low-emissions generation, and the abatement achieved.

Relative to counterfactual electricity-sector emissions, the estimate of total abatement from the Chinese policies analysed is the third lowest of the study

countries, and the total subsidy equivalent is estimated to be the fourth lowest relative to GDP. Most of the subsidies paid (and abatement achieved) are attributed to wind power. Biomass contributes some abatement, and solar PV a negligible amount (table 4.4).

Table 4.4 **Effects of emissions-reduction policies, China**
2009, 2010

Policy name	*Policy type*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
		A$m (2010)	Mt CO_2	A$/t CO_2
FITs for large-scale renewables				
Wind FITs	FITs	1 346–1 731	35–45	30–49
Biomass FITs	FITs	353–397	5–6	58–81
Solar PV programs[a]				
Jianagsu Solar PV feed-in tariffs	FITs	83	0.2	356–435
Golden Sun Subsidy Scheme	Capital subsidy	43–81	0.3	124–285
Subsidies for solar PV in buildings	Capital subsidy	10–18	0.1	72–168
'Large Substitute for Small'	Generator upgrades	0–1 251[b]	119–174	0–11
Total (not including LSS)		**1 835–2 309**	**41–52**	**35–57**
Total (including LSS abatement)[c]		**1 835–2 309**	**159–226**	**8–15**

a Due to overlap between the Jiangsu FITs and the solar PV capital subsidies, the Commission assumed that 20 per cent of the abatement from the capital subsidies overlaps with the abatement attributed to the Jiangsu FITs. **b** The lower-bound estimate of the subsidy equivalent for the LSS program was estimated to be less than zero. However, because negative numbers are not meaningful, the lower bound is reported as zero. **c** Does not include the subsidy equivalent for the LSS.

Source: Appendix E.

The LSS program appears to be financially cost effective, with the savings in operating costs that come from using large, modern power plants outweighing the capital costs of the new plants under most assumptions (box 4.4). The implication is that if production and investment decisions in China's electricity sector were based on market incentives, it is likely that the smaller plants would have been replaced by more efficient plants without government intervention. In other words, the abatement achieved through the LSS program would have been achieved anyway. For this reason, the estimates of the impacts of the LSS program are reported here, but the program is excluded from the international comparisons. This is consistent with how cost-effective improvements in the efficiency of generators in other countries have been treated.

Box 4.4 **The 'Large Substitute for Small' Program**

The 'Large Substitute for Small' program (LSS) aims to decommission small inefficient thermal power plants and replace them with larger, more advanced plants. Since its introduction in 2006, the LSS has resulted in the closure of around 71 gigawatts (GW) of small thermal plants. According to data from the International Energy Agency, over the same period, around 569 GW of new coal power plants have been built (IEA 2010c).

It appears that the program has been pursued for a number of reasons, including increasing the efficiency of the electricity supply system, energy security, reducing greenhouse gas emissions and other environmental reasons.

The LSS program involves financial costs (the capital costs of the investment in new plants) and benefits (the operating cost savings from using more efficient technologies). Taking these into account, the Commission estimated that, under most assumptions about parameter values, the LSS program delivers a net financial benefit — the estimated savings in operating costs exceed the annualised capital costs of new plants

Improvements in the efficiency of coal-fired generation were estimated to deliver emissions reductions in the range 119–173 Mt CO_2. However, this is not included when making cross-country comparisons of abatement in this study, because the LSS program does not impose a cost on the Chinese economy (relative to the counterfactual of not upgrading China's coal-fired plants). In order to be consistent internationally, such 'no regrets' measures have not been counted.

Source: IEA 2010c; Appendix E.

Even with abatement associated with the LSS program excluded from the total, the lower-bound implicit abatement subsidy estimate for China (A$35/t CO_2) is the lowest of all the study countries apart from New Zealand. This is partly due to the high emissions intensity of China's electricity generation sector, which leads to a relatively high amount of abatement when renewables are used. It also reflects the relative cost effectiveness of large-scale wind and biomass, which account for over 90 per cent of the total subsidy equivalent.

Under the twelfth Five Year Plan (2011–2015), the Chinese Government has committed to energy and emissions intensity targets that may have an effect on the electricity generation sector. There is little detail available on how these targets will be achieved, although the twelfth Five Year Plan establishes a goal of 'gradually establish[ing] a carbon trading market' (Pew Center on Global Climate Change 2011, p. 2). Media reporting also suggests that the Chinese Government is proposing to trial the introduction of some form of emissions trading scheme in six provinces before 2013 and nationwide by 2015 (Reuters 2011).

United States

The analysis covered two federal renewable energy policies (a production subsidy and a capital grant), nine state-based renewable portfolio standards (which set targets for renewables), and a range of Californian subsidies for solar power. Overall, the estimates account for most large-scale renewable energy in the United States (through the federal schemes) and around 70 per cent of US solar generation (through the Californian schemes).

The US abatement estimate is high in absolute terms, but below those of Germany, the United Kingdom and Australia as a proportion of counterfactual electricity sector emissions. As a proportion of GDP, the total subsidy equivalent estimate is lower than all study countries except Japan (table 4.5).

However, the total subsidy equivalent estimate for the United States is likely to be an underestimate. This is because, due to time and data constraints, many state and federal policies could not be included in the analysis (appendix K). In aggregate, it is likely that many renewable generators that received subsidies through the policies that were analysed also received additional subsidies through policies that were not included in the analysis. These unaccounted subsidies are likely to play an important role in the investment and production decisions of renewable generators, and as such their exclusion from the analysis is likely to understate the resource costs of using these technologies. On the other hand, because the renewable generators are likely to have been included through the analysis of other policies, most of the abatement associated with the policies that were excluded from the analysis is probably already captured. Any underestimation of the total subsidy equivalent would flow through to the implicit abatement subsidy.

Subsidies for renewables in the United States range from relatively modest (the federal production tax credit offers a A$24/MWh subsidy to wind, compared to the subsidy offered under Australia's RET of around A$40–60/MWh) to very generous (the Californian capital subsidies for solar PV, which equate to a subsidy of around A$200–250/MWh). However, the aggregate effect of the solar subsidies is relatively minor, because they constitute a small proportion of the total subsidies for renewables. The relatively low subsidies to large-scale renewables provide a further explanation for the relatively low implicit abatement subsidy.

Table 4.5 **Effects of emissions-reduction policies, United States**
2010

Policy name	*Policy type*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
		A$m (2010)	Mt CO_2	A$/t CO_2
Federal policies and renewable portfolio standards		2 684–3 047	66	41–46
Renewable Electricity Production Tax Credits	Tax credit	1 708	..[a]	..
Treasury grants	Capital subsidy	418–782	..[a]	..
State renewable portfolio standards	REC schemes	557	..[a]	..
Californian capital subsidies		202–292	0.4–0.7	305–651
Californian Solar Initiative		125–148	..[b]	..
New Solar Homes		2–4	..[b]	..
Self Generation Incentive Program		42–78	..[b]	..
Emerging Renewable Program		33–62	..[b]	..
Total		**2 886–3 339**	**67**	**43–50**

a Due to overlaps between the federal policies and the state renewable portfolio standards, the Commission estimated abatement and implicit abatement subsidies for these policies as a group. **b** Due to overlaps between the Californian subsidies for solar PV, the Commission estimated abatement and implicit abatement subsidies for these policies as a group. **..** Not applicable.

Source: Appendix K.

As well as the subsidies for renewable energy, there is one regional ETS that is currently operating in ten north-eastern states, and another ETS that is scheduled to begin in 2012 (box 4.5). These schemes are not currently leading to significant abatement, although this may change in future years as the emissions caps tighten.

Another measure that could have significant effects on emissions from the US electricity generation sector is the US Environmental Protection Agency's emissions standards for large emitters of greenhouse gases (chapter 2). Under these standards, large emitters will have to hold permits to continue to operate. Eventually, the requirements could apply to around 70 per cent of US greenhouse gas emissions (US EPA 2011b).

Box 4.5 **Emissions trading schemes in the United States**

The Regional Greenhouse Gas Initiative

The Regional Greenhouse Gas Initiative covers the electricity sector in ten north-eastern states. The objective of the scheme is to reduce electricity-sector emissions in these states to 10 per cent below 2009 levels by 2018.

The initial cap was set to stabilise electricity-sector emissions in these states at 171 Mt CO_2 annually until 2014. This cap does not appear to be binding, as emissions in 2009 were approximately 112 Mt (NYSERDA 2010b), and as such the ETS cannot be credited with any supply-side abatement. This observation is supported by the permit price, which was at the minimum reserve price throughout much of 2010 (US$2.05/t CO_2 (A$2.23)). As the cap begins to tighten, the permit price may rise, leading to some supply-side abatement in the future.

In May 2011, the Governor of New Jersey announced that the state would withdraw from the scheme, leaving nine states remaining (AP 2011).

The Western Climate Initiative

The Western Climate Initiative is an agreement to implement an ETS in seven US states and four Canadian provinces in 2012. The WCI (2010a) has recommended that the initial cap on emissions be set at the level of projected business-as-usual emissions. Therefore, it is expected that, if implemented, the permit price and abatement will initially be close to zero. As the cap tightens, the scheme could lead to significant abatement. The Californian Air Resources Board (CARB (US) 2010) projected that the permit price in California in 2020 will be in the range of US$25–US$162/t CO_2 (A$27–176), depending on the extent of complementary policies in place.

Currently, it appears that only California is fully committed to implementing an ETS in 2012. Arizona and Utah pulled out of the scheme in 2010, New Mexico in early 2011, and as yet Oregon, Washington and Montana have not passed enabling legislation.

Sources: AP (2011); CARB (US) (2010); NYSERDA (2010b); WCI (2010a).

United Kingdom

The analysis for the United Kingdom covered four policies: the European Union ETS; the Renewables Obligation (a REC scheme); the Climate Change Levy (a differential electricity tax with lower rates for electricity from renewable energy sources); and the Offshore Wind Capital Grants Scheme. These policies cover the main technologies leading to abatement in the United Kingdom — gas, combined heat and power, and renewables. However, there are significant interactions between the policies, and thus attributing abatement and an implicit abatement

subsidy to each policy was not possible (appendix J). Instead, implicit abatement subsidy estimates for the United Kingdom are attributed to technologies.

Relative to the other countries, estimates of total abatement (as a proportion of counterfactual electricity sector emissions) and the total subsidy equivalent (as a proportion of GDP) are high in the United Kingdom — behind only Germany, and around double that of the next highest country (Australia) (table 4.6).

Around half of the abatement was estimated to have come from the incentive that the European Union ETS gives electricity generators to switch from coal to gas. The resource cost of this abatement is relatively low (the implicit abatement subsidy is equal to the European Union ETS permit price, which was around A$29/t CO_2 in 2009-10). The estimates of the subsidy equivalent and abatement are reported in a relatively wide range (A$115–A$403 million and 4–14 Mt CO_2 respectively). This reflects uncertainty about the extent of fuel switching in the United Kingdom. The estimates were based on academic literature that suggests that the European Union ETS has increased the use of gas-fired generation by between 5 and 20 per cent.

Most of the rest of the abatement was attributable to subsidies paid to renewable energy — primarily through the Renewables Obligation (a REC scheme). This scheme also accounts for the majority of the total subsidy equivalent estimate. The Renewables Obligation mainly appears to subsidise wind, biomass and waste, which are generally relatively low cost. However, the Renewables Obligation target has not been met, and as such the permit price is driven by the 'fine' for not surrendering a certificate. This leads to a relatively high implicit abatement subsidy for large-scale renewables in the United Kingdom. (The relatively low emissions intensity of the counterfactual electricity source also plays a role in elevating the implicit abatement subsidy.)

An important factor to take into account when assessing the UK results is that because the United Kingdom participates in the European Union ETS, any abatement in the electricity sector that is achieved through subsidies to renewables or combined heat and power will simply be offset by higher emissions elsewhere in the European Union. This is because the European Union ETS sets a binding cap on total European Union emissions from a number of sectors (including electricity generation). If the UK Government chooses to subsidise high-cost abatement through renewables, this simply reduces the burden on other countries. Overall, European Union emissions will ultimately be determined by the ETS cap.

Table 4.6 **Effects of emissions-reduction policies, United Kingdom**
March 2009 – April 2010

Policy name	*Policy type*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
		A$m (2010)	Mt CO_2	A$/t CO_2
Coal–gas switching				
European Union ETS	ETS	115–403	4–14	29
Subsidies to combined heat and power				
Climate Change Levy	Differential electricity tax	30–38	2	21–26
Subsidies to renewable energy		1 897–1 993	7–12	160–294
European Union ETS	ETS	278	..[a]	..
Renewables Obligation	REC scheme	1 508–1 573	..[a]	..
Climate Change Levy	Differential electricity tax	105–131	..[a]	..
Offshore Wind Capital Grants Scheme	Capital grants	6–11	..[a]	..
Total		**2 001–2 258**	**12–27**	**75–198**

a Policy overlaps meant that it was not possible to estimate the abatement attributable to individual policies that provide subsidies to renewable energy sources. **..** Not applicable.

Source: Appendix J.

Germany

The analysis covered three policies: the European Union ETS, FITs for renewables, and production subsidies for combined heat and power. Of all the countries analysed, Germany has the highest total subsidy equivalent estimates (both in absolute terms and as a proportion of GDP), and the highest abatement relative to counterfactual electricity sector emissions (table 4.7).

In Germany, the European Union ETS has led to some relatively low-cost abatement through fuel switching (from coal to gas). The implicit abatement subsidy is equal to the European Union ETS permit price (around A$20/t CO_2 in 2010). However, in the year of analysis (2010), Germany had relatively little surplus gas-fired generation capacity. This placed a constraint on the ability of German generators to increase their use of gas in the short term, and meant that abatement through coal-gas switching was less than in the United Kingdom in the same year. In the longer term, the European Union ETS gives electricity generators an incentive to invest in more gas-fired capacity, which would be expected to lead to emissions reductions.

Table 4.7 **Effects of emissions-reduction policies, Germany**
2009, 2010

Policy name	*Policy type*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
		A$m (2010)	Mt CO_2	A$/t CO_2
Renewable Energy Sources Act	FITs	8 104–9 789	59	137–166
Combined Heat and Power Act	FITs	399	7–10	40–55
European Union ETS	ETS			
Switch from coal to gas		15–80	1–4	20
Interaction with feed-in tariffs		1 365	..[a]	..
Indirect subsidy to combined heat and power		136	..[b]	..
Total		**10 019–11 769**	**67–73**	**137–178**

[a] Abatement was attributed to the Renewable Energy Sources Act. [b] Abatement was attributed to the Combined Heat and Power Act. **..** Not applicable.

Source: Appendix F.

At the other end of the scale, Germany's FIT regime is relatively costly. Implicit abatement subsidies were estimated to be as high as A$864/t CO_2 (for solar PV) (appendix F). Furthermore, because Germany participates in the European Union ETS, this abatement is offset completely by an increase in emissions from other sectors, and from other countries that participate in the scheme. For example, Traber and Kemfert (2009) found that Germany's FIT-induced electricity-sector emissions reductions would be offset by higher emissions from electricity generators in Spain and Italy. This could be described as 'intra-Europe carbon leakage'. German electricity consumers face higher electricity prices to pay for the FITs, but any emissions reductions in Germany are entirely offset by higher emissions in other countries that do not impose the same burdens on their consumers.

Japan

Seven policies were analysed — the Renewable Portfolio Standard, two capital subsides for wind, the Petroleum and Coal Tax, and three measures relating to solar PV. The results suggest that Japan achieved relatively little abatement through these policies in the year of analysis (ahead of only South Korea in proportionate terms), and had the lowest total subsidy equivalent as a proportion of GDP (table 4.8).

The total subsidy equivalent is likely to be somewhat underestimated because the Commission was unable to estimate the full effects of two national-level capital subsidies for renewable energy that have been in operation since 1997 (appendix G). Including these policies in the analysis would likely increase the total subsidy equivalent and abatement estimates. However, since 2002, the

Renewable Portfolio Standard has covered the majority of renewable energy generation in Japan. Thus, abatement from renewable generators installed after this period is likely to have been covered in the estimates.

Moreover, the relatively little abatement that Japan achieved through these policies was delivered at relatively high cost (the average implicit abatement subsidy was estimated to be in the range A$156–A$287/t CO_2 — among the highest of the study countries). Japan's high implicit abatement subsidy is explained by two factors. First, the relatively low emissions intensity of the electricity that is displaced by renewables. Second, subsidies to solar PV are high, relative to its contribution to total abatement.

Table 4.8 **Effects of emissions-reduction policies, Japan**
April 2009 – March 2010

Policy name	*Policy type*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
		A$m (2010)	Mt CO_2	A$/t CO_2
Policies that support renewables other than solar		429–541	2–3[a]	145–239[c]
Renewable Portfolio Standard	REC scheme	300	..	..
Program for Promoting the Local Introduction of New Energy[b]	Capital subsidy	19–35	..	..
Project for Supporting New Energy Operators[b]	Capital subsidy	110–206	..	..
Solar PV programs		225–354	1[c]	170–349[d]
National PV subsidies	Capital subsidy	147–274	..	..
New Buyback Program	FIT	76	..	..
Tokyo PV subsidies	Capital subsidy	2–4	..	..
Petroleum and coal tax	Fuel tax	13–39	..	..
Total		**669–940**	**3–4**	**156–287**

a Due to overlaps between the Renewable Portfolio Standard, the Program for Promoting the Local Introduction of New Energy, and the Project for Supporting New Energy Operators, abatement could not be attributed to individual measures. Therefore, the Commission estimated abatement and the implicit abatement subsidy from these measures as a group. **b** The Commission was only able to obtain data on the wind component of these capital subsidies. **c** Due to overlap between the three solar programs, the Commission estimated abatement and the implicit abatement subsidy from these measures as a group. **..** Not applicable

Source: Appendix G.

No abatement was attributed to the Petroleum and Coal tax because at the current level of the tax it was considered unlikely to have resulted in any fuel switching between fossil-fuel sources (although the tax does provide a small subsidy to renewables by increasing the price of electricity).

The Japanese Government has also foreshadowed the introduction of an ETS and a system of FITs that would replace the existing RPS. Little information is available on these measures at this time. However, if they were to be introduced, they could have a large effect on emissions, subsidies for low-emissions generation, and the implicit abatement subsidy estimate for Japan's electricity generation sector.

South Korea

As is the case for Japan, the policies that were analysed for South Korea appear to have achieved relatively little abatement at relatively high cost (table 4.9). This is largely a result of the focus of the South Korean policies on solar PV generation. Overall, approximately 85 per cent of the estimated total subsidy equivalent was provided to solar. The policy with the largest impact on the total subsidy equivalent estimate — the FITs — offered rates of approximately A$555/MWh to solar, compared to around A$15/MWh for wind generation.

The abatement estimate for the South Korean policies was the lowest out of the study countries (in proportionate terms), while its implicit abatement subsidy is by far the highest.

In contrast, the Korea Certified Emission Reductions (KCERs) scheme had an implicit abatement subsidy that is 50 to 100 times lower than that of the FITs. The scheme appears to be achieving abatement mainly through increasing the use of gas-fired generation and efficiency improvements in existing generation. However, this scheme is relatively small compared to the FITs, and thus it did not have a large impact on the estimated average implicit abatement subsidy for South Korea.

While the analysis included those emissions-reduction policies that were both material and in operation over the study period, South Korea has committed to a number of other policies that may lead to additional abatement in the future. However, the subsidies these policies would provide to lower-emissions generation are unclear. The policies include:

- a REC scheme commencing in 2012 that will replace the FITs, and will set a target for 2 per cent of electricity to be sourced from renewable generation in 2012, rising to 10 per cent by 2022
- a system of mandatory emissions-reduction agreements, including agreements covering 36 electricity generators commencing in 2012.

In addition, the South Korean Government has proposed an ETS for introduction in 2015. However, at this stage details of the policy are unclear.

Table 4.9 **Effects of emissions-reduction policies, South Korea**
2010

Policy name	*Policy type*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
		A$m (2010)	Mt CO_2	A$/t CO_2
Korean Feed-in Tariffs	FITs	255	0.6–1	261–435
Korea Certified Emission Reductions	An offset scheme directed at non-renewable electricity	1	0.3	5
General Deployment Subsidy Scheme	Capital subsidy	5–10	0.0	275–518
Regional Deployment Subsidy	Capital subsidy	20–38	0.1	301–564
One Million Green Homes	Capital subsidy	16–29	0.0	617–1 156
Loan Incentive Program	Low-interest loans	15–45	..[a]	..[a]
Total		**313–379**	**1.2–1.4**	**225–401**

[a] Due to overlaps with other policies, abatement and the implicit abatement subsidy for preferential loans were not estimated. **..** Not applicable.

Source: Appendix I.

New Zealand

Only one policy was analysed for New Zealand: its ETS. This has been in place since 2008, with electricity being covered by the scheme since 2010. During the transitional period, firms with ETS obligations are only obliged to surrender one permit for every two tonnes of emissions, and have the option of paying NZ$25 (A$19) rather than purchasing a permit. The net effect is that the implicit abatement subsidy under the scheme is capped at NZ$12.50/t CO_2 (A$10). Permit prices in 2011 have been around NZ$19–21 (A$14–16), meaning that the implicit abatement subsidy has been around A$7–8/t CO_2.

The Commission did not estimate how much abatement is being achieved under the ETS. Emissions are not capped under the scheme and international permits or offsets may be used for compliance. As a result, the permit price is low and it is likely that supply-side abatement is currently modest. However, this could change in the future depending on the policy settings and their impact on the permit price.

Emissions from New Zealand's electricity sector are currently relatively low due to the fuels used. In 2010, around 74 per cent of electricity in New Zealand was generated using renewables (mainly hydro, geothermal and wind). This suggests that New Zealand has fewer opportunities to switch fuels than is the case in countries that use more fossil fuels. However, the New Zealand Ministry of Economic Development (2010b) has forecast that, as a result of the ETS, the

country's only coal-fired power plant will close by around 2021, and that future growth in electricity demand will be met by increased use of renewables.

4.4 Demand-side abatement

The previous section quantified the extent to which policies lead to supply-side abatement (abatement due to generators shifting to less emissions-intensive technologies). Emissions-reduction policies can also lead to demand-side abatement by electricity consumers (abatement due to lower electricity consumption) if the policies raise electricity prices.[1]

Given data and other constraints (discussed below), the Commission was not able to precisely quantify the extent to which policies increase electricity prices and thereby lead to demand-side abatement. Instead, this section presents illustrative estimates of demand-side abatement based on a number of simplifying assumptions. The consumption cost — defined as the consumer valuation of forgone electricity consumption, less the valuation of other goods that can be purchased with the diverted expenditure — is also illustrated by using simplifying assumptions.

The impact of emissions-reduction policies on retail electricity prices has been a prominent issue in recent debate about Australia's actions to address climate change, and is likely to continue to be so under current regulatory arrangements (Sims 2010). For example, the NSW electricity-market regulator (IPART 2011a) recently issued a draft decision that would allow retailers to raise regulated tariffs by around 18 per cent on 1 July 2011. Most of this increase (10 per cent) was to cover a rise in network costs (transmission and distribution of electricity). However, much of the remaining increase (6 per cent) was to cover the cost of changes made to the RET in January 2011.[2] This would be in addition to the cost previously allowed for the pre-existing RET, which MMA (2010) estimated would have raised retail electricity prices by around 4 per cent at a national level from 2010 to 2015.[3] Feed-in tariffs and other emissions-reduction policies — such as the NSW

1 Demand-side abatement can also result from policies that encourage consumers to increase their energy efficiency at a given electricity price. As noted in chapter 3, energy-efficiency policies are not included in this study's quantitative analysis due to uncertainty about their impacts.

2 About a month after IPART released its draft decision, the Australian Government (Combet and Dreyfus 2011) announced adjustments to the 'solar credits' used for the small-scale component of the RET, which it claimed would reduce the cost to electricity users by around half in 2012.

3 MMA (2010) estimated that, if the RET that applied in 2010 had remained unchanged, it would have increased retail electricity prices by 4.0 per cent over 2010–2015, provided the Carbon Pollution Reduction Scheme (CPRS) had started in 2013. The estimated price increase was 4.2 per cent if the CPRS started in 2014.

Greenhouse Gas Reduction Scheme — have also been argued to have contributed to the growth of electricity prices in recent years (Garnaut 2011).

Estimation approach and interpretation

Details about the approach and data used to quantify demand-side abatement and consumption costs are provided in appendix L. In summary, the Commission estimated a range within which demand-side abatement might occur, given the total subsidy equivalent estimates from the supply-side analysis, and the bounds within which the own-price elasticity of demand appears to lie.[4]

The resulting estimates should be considered illustrative, or at best only indicative, rather than being a definitive assessment of demand-side abatement and final consumer-price impacts. This is because it was necessary to make various simplifying assumptions to complete the task within the time and data constraints faced by the study. These include the following:

- It was assumed that the cost borne by electricity generators due to emissions-reduction policies was passed through the value chain and ultimately on to consumers, unless it was clear that the policy was explicitly funded by taxpayers. This provides an upper-bound estimate of the actual increase in electricity prices, since no account was taken of factors — such as retail-price regulation and competitive pressures — that can limit producers' scope to pass cost increases on to their customers.
- Differences in policy coverage and electricity prices between different groups of customers — such as residential, commercial and industrial — were factored into the calculations where possible. However, the resulting estimates are unlikely to be as accurate as those generated by industry models that more accurately capture differences between customer groups, including their responsiveness to price changes.
- No account was taken of the compensation that governments sometimes provide to consumers to cushion the price impacts of emissions-reduction policies. Thus, the estimates could overstate the reduction in electricity demand, associated demand-side abatement, and consumption costs.

4 The own-price elasticity of electricity demand measures the proportional change in electricity consumption in response to a unit change in the price. Estimates of this elasticity are typically in the range of -0.2 to -0.7 (appendix L). On this basis, two alternative elasticities were used to quantify demand-side abatement: -0.2 and -0.7. This provided a range within which the true demand response seems most likely to occur, given the empirical evidence on elasticities.

- For a given country, it was common for one or more variables used in the calculations to be unavailable for the same year as the estimated total subsidy equivalent. In such cases, a mixture of data for adjacent years had to be used. Data constraints also led to inconsistent time periods across countries. Thus, the estimates should only be viewed as being illustrative of recent impacts, rather than a precise quantification of those in a specific year.

The supply-side estimates presented earlier in this chapter excluded implicit subsidies that do not induce abatement. This was necessary in order to approximate the resource cost of abating emissions. In contrast, the demand-side estimates presented here include all implicit subsidies associated with a given policy, regardless of whether any abatement is induced. This is done on the grounds that, while no abatement may be achieved, there is a cost and, if it is not explicitly funded by taxpayers, it will be passed on to consumers as higher electricity prices.[5]

Illustrative estimates

The illustrative demand-side estimates are provided in table 4.10. In summary, they would suggest that demand-side abatement may have been relatively minor in percentage terms in most of the analysed countries. This is due to average implicit abatement subsidies and ETS revenues being relatively insignificant when spread across a country's total electricity consumption.

The exceptions are Germany and the United Kingdom, where the estimates suggest that emissions-reduction policies may have raised electricity prices in the range of 12 to 17 per cent, and reduced emissions by 3 to 19 per cent. For Germany, more than half of the price uplift was due to FITs, and almost all of the remainder was due to the European Union ETS. For the United Kingdom, the price uplift was largely due to four policies — the Climate Change Levy, Carbon Emissions Reduction Target, Renewables Obligation, and the European Union ETS.

5 The cost of levying taxes to fund the administration of emissions-reduction policies, and to finance taxpayer-funded abatement subsidies, could be passed on to electricity consumers through means other than electricity prices. The Commission has not estimated this in its demand-side analysis.

Table 4.10 **Illustrative estimates of demand-side impacts for electricity[a]**

		Australia[b]		*China*[c]		*Germany*	
	Unit	*Low*	*High*	*Low*	*High*	*Low*	*High*
Change in:							
retail electricity price	A$/MWh	3	4	1	1	25	28
electricity consumption	GWh	- 479	-3 772	-4 216	-28 771	-14 982	-64 968
emissions	Mt CO_2	–	-5	-3	-29	-8	-71
Percentage change in:							
retail electricity price	%	1	2	1	1	12	14
electricity consumption	%	–	-2	–	-1	-2	-10
emissions	%	–	-2	–	-1	-3	-19
Consumption cost:[d]							
total amount	A$m	1	7	2	11	184	900
per tonne of abatement[e]	A$/t CO_2	3	2	–	–	23	13

		Japan		*New Zealand*		*South Korea*	
		Low	*High*	*Low*	*High*	*Low*	*High*
Change in:							
retail electricity price	A$/MWh	3	3	1	1	–	–
electricity consumption	GWh	-2 050	-10 482	- 62	- 483	–	–
emissions	Mt CO_2	-1	-6	–	–	–	–
Percentage change in:							
retail electricity price	%	1	1	1	2	–	–
electricity consumption	%	–	-1	–	-1	–	–
emissions	%	–	-1	-1	-4	–	–
Consumption cost:[d]							
total amount	A$m	3	14	–	–	–	–
per tonne of abatement[e]	A$/t CO_2	3	2	1	1	–	–

		United Kingdom		*United States*	
		Low	*High*	*Low*	*High*
Change in:					
retail electricity price	A$/MWh	28	28	–	–
electricity consumption	GWh	-13 260	-50 949	-1 288	-9 741
emissions	Mt CO_2	-5	-35	-1	-9
Percentage change in:					
retail electricity price	%	17	17	–	–
electricity consumption	%	-3	-12	–	–
emissions	%	-3	-19	–	–
Consumption cost:[d]					
total amount	A$m	185	711	–	1
per tonne of abatement[e]	A$/t CO_2	35	20	–	–

a Monetary amounts are in Australian dollars, based on the following exchange rates for A$1: CNY 6.21; €0.70; ¥79.37; NZ$1.30; £0.54; and US$0.92. **b** Australian estimates understate current impacts because they are based on 2010 RET certificate prices, which were low due to an oversupply of certificates. **c** Chinese estimates overstate impacts because they overlook the fact that electricity prices are often set below costs. **d** Consumers' valuation of forgone electricity consumption, less the valuation of other goods that can be purchased with diverted expenditure. **e** This is typically greater for the 'low estimate' because the consumption cost is spread across a smaller reduction in emissions. – Nil or rounded to zero.

Source: Productivity Commission estimates.

In absolute terms, the estimates also suggest that there may have been a large amount of demand-side abatement in China (emissions reduction in the range of 3–29 Mt CO_2). However, this is likely to significantly overstate Chinese demand-side abatement because it assumes that electricity generators always pass on their costs, including those linked to emissions-reduction policies, to consumers. In practice, it appears that Chinese retail electricity prices are often set below the cost of production, particularly for coal-fired generators, and this has led to significant losses for many producers (China Securities Journal 2011; EIU 2011; Lan 2010).

For Australia, the estimates suggest that the price increase from all analysed policies was in the range of 1 to 2 per cent in 2010. It is possible that this national estimate conceals significant differences between states and territories.

Most of the estimated price increase for Australia was due to the version of the RET analysed in this chapter — the (expanded) RET that existed up until the end of 2010. In comparison, MMA (2010) forecast that that version of the RET would increase electricity prices by around 4 per cent over 2010 to 2015. It appears that MMA's higher estimate can be largely explained by the retail prices and REC prices it used in its calculations:

- MMA based its estimates on a REC price of around A$55 to A$70 over 2010 to 2015, whereas the Commission used REC prices that ranged from A$37 to A$60.
- MMA estimated its percentage price change relative to an expected retail price of around A$115/MWh for 2010 to 2015, which was lower than the prices observed by OTTER (2010) and used by the Commission in its calculations (A$163/MWh and A$283/MWh).

Using the same REC and retail prices as MMA, the Commission's approach would result in an estimated retail price increase of up to 3.4 per cent in 2010 for the RET alone, which is closer to MMA's results.

Recent changes to the RET are likely to mean that the price increases estimated by MMA are more representative of the RET's future impacts.[6] The RET scheme was changed significantly in January 2011 by splitting it into small and large-scale components. This was done in response to concerns that 'the inclusion of small-scale technologies and their impact on the renewable energy certificate (REC) market [was] delaying investment in large-scale renewable energy projects' (Australian Government 2010, p. 6; ECALC 2010, p. 2). The number of RECs created in 2010 was far greater than what had to be surrendered in that year. This

6 MMA (2010) estimated that, with the recent changes, the RET would raise retail electricity prices in the range of 4.2 to 4.4 per cent over 2010 to 2015.

placed downward pressure on REC prices, to the extent that it raised concerns that the RET did not provide a sufficient incentive to invest in large-scale renewable generation (ECALC 2010). As noted above, IPART (2011a) has proposed a 6 per cent increase in NSW regulated tariffs to cover the cost of the changes made to the RET.[7]

[7] This is more than the average national increase in retail electricity prices that MMA (2010) estimated over 2010 to 2015 for the most recent version of the RET (4.2 to 4.4 per cent). However, previous estimates by MMA (2009) suggest that the RET causes a higher percentage increase in retail electricity prices in New South Wales than in other states.

5 The road transport sector

Key points

- The Commission has analysed the costs and abatement for a selection of road transport fuel policies (fuel taxes and biofuel policies).
  - This analysis provides an illustration of the challenges in estimating abatement costs in sectors other than electricity.
  - However, the limited coverage of the analysis means that the results do not reflect all relevant policy-induced costs and abatement in the study countries.
- Both fuel taxes and biofuel policies often have multiple objectives.
  - Where policies are primarily in place for other reasons, reductions in emissions could be seen as an incidental outcome, at low or zero cost.
- In general, policies targeting greenhouse gas emissions from road transport that are broad in scope are likely to reduce emissions more efficiently and cost effectively than policies that target specific technologies or activities.
- Across all study countries, biofuel policies make a small contribution to abatement in the road transport sector at a relatively high cost.
  - These policies are narrow in scope (and can be even narrower where preference is given to particular biofuel feedstocks).
  - The abatement from biofuel policies is highly sensitive to the feedstock used, taking into account life-cycle emissions.
  - Australia's biofuel policies in 2010 led to abatement of 0.6 per cent of counterfactual road transport sector emissions at a cost of A$364 per tonne of CO_2-e abated.
- Fuel taxes are a broad based policy (within road transport) and can potentially have a large impact on sectoral emissions at relatively low cost.
  - However, fuel taxes are levied for a range of other purposes and it is difficult to attribute the costs of fuel taxes to the abatement achieved.
  - The average cost per tonne of abatement is higher in countries that have higher fuel taxes.
  - In 2009-10, fuel taxes reduced emissions from road transport by 8 to 23 per cent in Australia at an average cost of around A$57–59 per tonne of CO_2-e.

This chapter presents the Commission's quantitative analysis of abatement and costs for a selection of road transport policies. The first two sections discuss the scope of the quantitative analysis and the approach used to estimate abatement costs. The final section presents results by country on both the supply side and demand side.

5.1 Reducing emissions from road transport

The road transport sector includes all transportation of passengers and freight by road, such as commercial and private vehicles, on-road public transport (for example, buses), small and large commercial goods vehicles and government fleet vehicles. Road transport represents a significant proportion of total greenhouse gas emissions in all study countries, ranging from 5 per cent in China to 26 per cent in New Zealand (figure 5.1). By focusing on road transport, the Commission's analysis covers the majority of emissions in each study country's transport sector. Further analysis of emissions and road transport fuel use is provided in Appendix M (available on the Commission's website).

A range of policy tools are being used by governments to reduce transport emissions. For example, governments tax or subsidise fuels and vehicles based on their greenhouse gas emissions intensity. Chapter 2 provides an overview of the types of policies that study countries use to reduce emissions more generally in the transport sector.

The scope of quantitative analysis

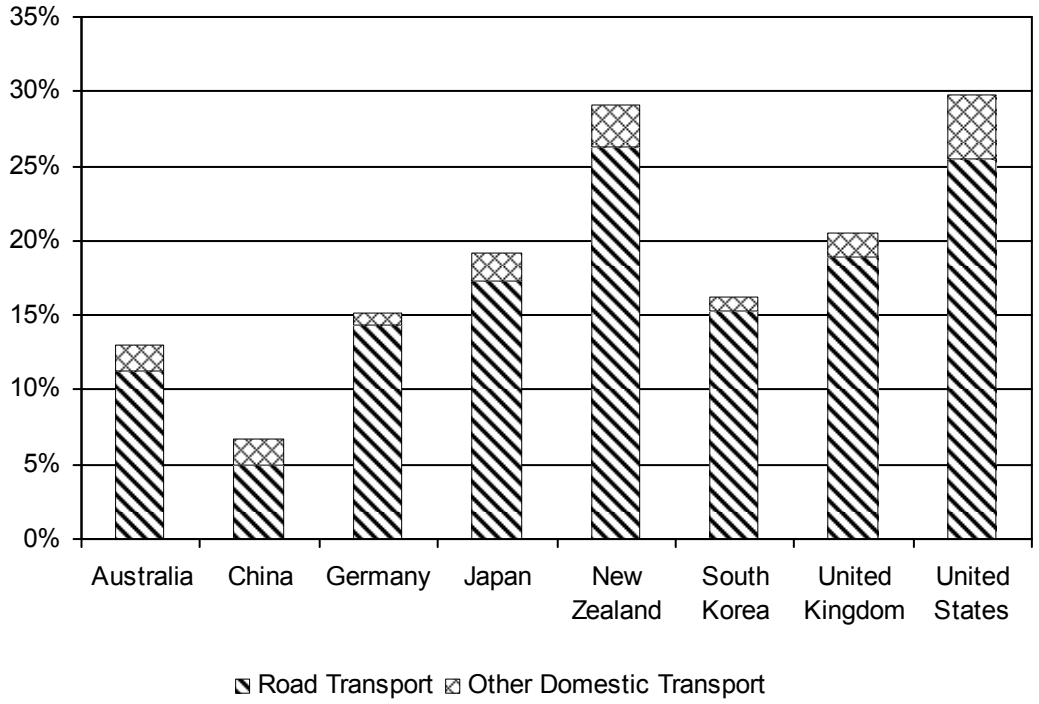
The Commission has identified over 100 policies that apply to the road transport sectors of the study countries, and has selected a subset for more detailed analysis. The quantitative analysis was restricted to road transport policies that:

- penalise emissions or provide an incentive for abatement
- have a material impact on a country's emissions and/or impose significant total costs
- have a reasonably direct impact on greenhouse gas emissions.

A further issue was whether it was *feasible* to quantify the costs and abatement of policies — some policies met the criteria in principle, but could not be included due to a lack of suitable data, or high levels of uncertainty regarding abatement or cost.

Figure 5.1 **Road transport greenhouse gas emissions as a percentage of total national emissions[a,b]**

2008 (or most recent year available)



a 'Other domestic transport' includes emissions from fuel used for domestic civil aviation, railways, domestic water-borne navigation, pipeline transport, fishing, off-road transport and other non-specified domestic transport emissions. Excludes emissions from fuel sold for use in aircraft or marine vessels engaged in international transport. **b** As China and South Korea do not have official reporting obligations under the Kyoto Protocol, national emissions are 2007 estimates from WRI (2010) and exclude emissions from land use change and forestry. Road transport and other domestic transport emissions for China and South Korea are 2008 estimates from the IEA (2010a).

Sources: IEA (2010a); UNFCCC (2011a); WRI (2010).

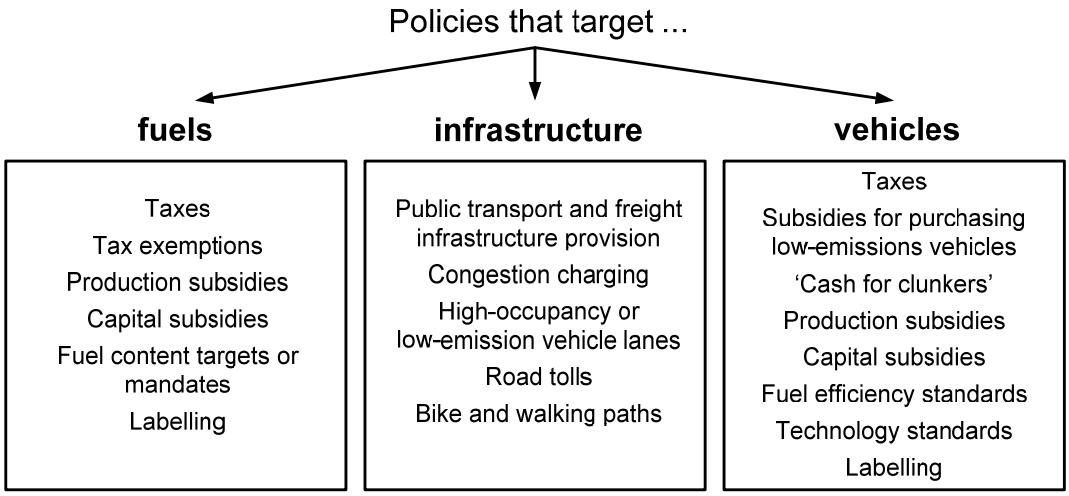
Road transport fuels

One group of policies that satisfied the Commission's criteria targets road transport fuels (figure 5.2), comprising biofuel policies and fuel taxes.

- The analysis of biofuels covers several types of policy, including tax exemptions, production subsidies and fuel content mandates (where material, and sufficient data were available).
  - Some policies, such as fuel content labelling requirements, were not analysed as the extent to which these policies led to abatement is uncertain and the linkages to greenhouse gas emissions too indirect (chapter 3).

- The analysis of fuel taxes covers all taxes that specifically target fuels (such as excise), but not broad-based consumption taxes, which usually do not provide differential treatment of transport fuels.
  - It also includes explicit carbon prices that cover transport fuels, as these are typically levied on fuel suppliers in a similar way to fuel excise (at present, of the countries studied only the New Zealand Emissions Trading Scheme (ETS) covers transport fuels).

Figure 5.2 **Road transport policies**



Not all transport-fuel policies can be considered primarily climate change measures. For example, fuel taxes — which are in place in every study country — are levied to meet a range of objectives, such as to fund road provision and maintenance, reduce congestion or to raise general revenue. These taxes may have net benefits where they address other objectives.

However, fuel taxes raise the price of fuel, and in so doing, reduce fuel demand and greenhouse gas emissions. Some study countries, such as Japan, have raised (or committed to raise) their fuel taxes with an explicit objective of reducing greenhouse gas emissions (chapter 2). Although a relatively direct measure, fuel taxes do not specifically target greenhouse gas emissions where they are levied as a flat rate on each litre of fuel. Nevertheless, since fuel taxes clearly provide an incentive for consumers to use less fuel — and thereby have a significant impact on emissions — they have been included in the analysis.

Where policies meet other objectives, reductions in greenhouse gas emissions may be an incidental outcome and thus any resulting abatement may occur at low or zero cost. (However, it is difficult to separate the impacts and costs of multiple

objectives of policies.) For example, biofuel policies often have a range of objectives in addition to greenhouse gas mitigation, such as promoting regional development or improving energy security. The Commission has not attempted to apportion abatement by the objectives of a policy and thus the estimates provide an 'upper bound'.

Other road transport policies

Applying the criteria for policy selection to other policy types in the road transport sector led to a large number of policies being excluded from the analysis. One excluded category is transport infrastructure policies, such as the development of public transport systems or road tolling. These are adopted by governments for various purposes other than reducing greenhouse gas emissions. However, these policies may have significant impacts on greenhouse gas emissions over long time periods. For example, infrastructure and urban planning policies can affect the range of transport modes available to individuals and thus can shape the ways in which people respond to changes in fuel prices over time. In doing so, infrastructure and urban planning policies have complex links to greenhouse gas emissions and can interact with other policies, such as fuel taxes. These impacts are difficult to measure.

Policies that target vehicles according to their fuel efficiency or greenhouse gas emissions, such as differential vehicle registration and mandated emissions standards, have also been excluded from the analysis (box 5.1). Governments may utilise some of these policies in order to overcome deficiencies in the provision of information — where consumers are not fully informed about the potential fuel savings from purchasing more fuel-efficient vehicles — or as a way to internalise the costs imposed on others from vehicle greenhouse gas emissions. However, there are divergent views on the extent to which individuals understand the private costs and benefits of fuel efficient (lower-emissions) vehicles, with significantly different implications for the costs of these policies as a means of abatement (appendix C).

Further, policies that target vehicles are a relatively indirect measure to reduce greenhouse gas emissions. While the average emissions intensity or fuel efficiency of a vehicle can be observed, this is only one factor among several that can determine the emissions from a vehicle over its lifetime. Total vehicle emissions will also depend on the distance the vehicle is driven, the type of fuel used, road conditions, where the owner lives and his or her driving style. Moreover, many vehicle policies (such as fuel efficiency standards) apply only to new vehicles. Thus, they affect the national vehicle fleet incrementally over long time periods.

While the Commission has therefore not estimated cost and abatement for vehicle policies, discussion of their likely impacts is provided in appendix C.

Box 5.1 **Key transport terms used in this study**

- Biodiesel — a form of diesel fuel that is derived from plant or animal matter.
- Conventional fuels — the two most widely used road transport fuels, petrol and diesel.
- Diesel — a middle distillate derived from a petroleum refining process (also referred to as light fuel oil, distillate fuel oil or automotive gas oil in some countries).
- Ethanol — ethyl alcohol, most commonly derived from biomass and used as a vehicle fuel.
- Ethanol-blended fuel — a mixture of petrol and ethanol. The name used in some countries refers to the proportion of ethanol (for example, E10 is 10 per cent ethanol and 90 per cent petrol).
- Export parity price — the price that fuel producers could receive by selling fuel for export rather than selling fuel domestically.
- Import parity price — the cost of importing fuel (including transport and import costs).
- LPG — liquefied petroleum gases used as vehicle fuel.
- Petrol — automotive gasoline distilled from petroleum (this includes 'regular unleaded' and 'premium unleaded' in Australia).
- Petrol equivalent — a measure to compare fuel volumes (for example biofuels or diesel) consistently by energy content. It is the volume of petrol that has the same energy content as one litre of a given fuel.
- Petroleum — liquid hydrocarbons as extracted from the earth (often called oil or crude oil).
- Terminal gate price — the advertised price of fuel for sale at the terminal gate of refiners or importers, which is often used as a reference to determine actual wholesale prices to customers.

What this means for the scope of the road transport analysis

While emissions-reduction strategies in the road transport sector clearly extend well beyond biofuels and fuel taxes, the focus has been restricted to these policies. This narrowing of scope was necessary because other policies in the sector either do not provide costs or incentives that are sufficiently closely linked to greenhouse gas emissions, or result in costs and levels of abatement that are particularly difficult to assess. This means that reported estimates do not fully capture the costs of

emissions-reduction policies in the road transport sector nor the policy-induced abatement.

An analysis of road transport fuels provides a useful illustration of the difficulties in estimating abatement costs in a sector other than electricity. For one thing, the methodological approach (chapter 3) cannot be applied to the road transport sector in the same way. There are some key differences between these sectors which affect the process required to estimate abatement and costs. In particular, the transport sector does not involve one homogeneous product. Also, fuels are commonly traded on international markets.

It is important that estimates for road transport fuels are viewed in this context, and not interpreted as necessarily representative of abatement costs, or levels of abatement being achieved, in the road transport sector more broadly.

What the Commission has estimated

There are a range of biofuel assistance measures and fuel taxes in place in all study countries (table 5.1). The approach taken to estimating abatement costs for these policies differs for the two broad policy types, and also across individual policies.

Biofuel policies

All eight study countries provide some form of support to biofuels and often utilise several policy instruments for this purpose (table 5.1). To the extent that they are effective, biofuel policies can induce an increase in domestic biofuel consumption and displace consumption of more emissions-intensive conventional fuels (such as petrol and diesel) (box 5.1). This abatement occurs on the supply side of the fuel market.

The biofuel analysis focuses on the two main fuel markets in each country (petrol and diesel) for which there are biofuel substitutes (ethanol and biodiesel). The analysis was conducted separately for these two fuel markets.

Table 5.1 **Coverage of fuel policies**[a]

	Biofuel policies		
Country	*Subsidies*	*Fuel content mandates*[b]	*Fuel taxes*
Australia	Ethanol, biodiesel	..	Petrol, diesel
China	Ethanol, biodiesel	Ethanol	Petrol, diesel
Germany	Biodiesel, vegetable oil[c]	Ethanol, biodiesel	Petrol, diesel, LPG
Japan	Ethanol	..	Petrol, diesel, LPG
New Zealand	Ethanol, biodiesel	..	Petrol, diesel, LPG[d]
South Korea	Biodiesel	..	Petrol, diesel, LPG
United Kingdom	..	Ethanol, biodiesel	Petrol, diesel, LPG
United States	..	Ethanol, biodiesel	Petrol, diesel, LPG[e]

[a] Only policies that were included in the quantitative analysis are listed in the table. Biofuel policies that are not expected to lead to additional biofuel consumption have not been included. [b] Only mandatory schemes were included in the analysis (this does not include the mandate in New South Wales). [c] Pure vegetable oil is used in some vehicles in Germany, and is assumed to displace diesel. [d] Fuel taxes in New Zealand include the New Zealand ETS. [e] Fuel taxes in the United States include federal and state-level taxes.
.. Not applicable.

Sources: Appendixes N, O.

In all study countries, some substitution occurs between petrol and/or diesel and biofuels (usually with a low proportion of biofuel in a blend with conventional fuel). While biofuels are not perfect substitutes for petroleum-derived fuels — there are differences in energy content and octane or cetane rating — in most cases they are used to displace these fuels. The Commission's analysis assumes that differences between fuel types — apart from energy content — do not significantly affect the demand for transport fuels. Thus, it has been assumed that in the absence of government policy, consumers will only purchase biofuels where these are price competitive with petrol or diesel. That is, the prevailing market price of biofuels is expected to equal the petrol (or diesel) price (adjusted for energy content) in the absence of policy support.

The focus of the analysis is on *consumption* of biofuels in each country. Where biofuels are imported, these are incorporated in the analysis. In contrast, biofuels that are produced domestically, but exported and consumed in another country, are excluded. This captures the costs of reducing greenhouse gas emissions through biofuels that are consumed in the country only.

Estimating costs

In order to determine the average cost of abatement of biofuel policies, the Commission has estimated their subsidy equivalents. The subsidy equivalent represents the amount of financial assistance provided directly or indirectly to the

biofuels industry under the policy. Subsidy equivalents also give an upper bound estimate of the resource costs of these policies (chapter 3).

The Commission estimated subsidy equivalents for two types of biofuel policy: production subsidies and fuel content mandates. Production subsidies provide a subsidy to producers of biofuel for each litre of fuel produced, usually in the form of an excise exemption on the tax rate paid per litre of petrol or diesel for fuels that contain biofuel. Where an exemption or a reduced excise rate is provided for biofuel, the Commission has assumed that the production subsidy is equal to the rate of excise levied on petrol (for ethanol) or diesel (for biodiesel) minus the excise rate (if any) on the biofuel. An alternative approach would have been to assume that the 'counterfactual' excise rate (that is, the excise rate on biofuel without the exemption or concessionary rate) would be equal to the excise rate for conventional fuel adjusted for energy content. However, most study countries do not adjust their fuel excise rates for energy content and it was not clear which study countries would do so in the absence of subsidies for biofuels. As such, the counterfactual excise rate for biofuel is assumed to be the excise rate for conventional fuel with no adjustment for energy content.

Fuel content mandates can be in the form of blending requirements or quotas that apply to all fuel distributors, or to particular groups (for example, government agencies as part of government procurement policies[1]). Whatever their form, mandates are likely to increase domestic consumption of biofuels where they are 'binding' — that is, where the mandate increases consumption above what it would otherwise have been. By increasing demand for their product, the mandate provides an implicit subsidy for biofuel producers. Rather than receiving the petrol price for their output (adjusted for energy content), ethanol producers receive a premium above the petrol price.

In order to estimate this price premium, estimates of country-specific terminal gate prices for each type of fuel have been used (box 5.1). The analysis assumes that no individual country has a significant influence on world prices for petrol and diesel. Further, as each study country is a net importer of either crude oil or petroleum-derived fuels, it is assumed that domestic petrol and diesel prices are largely determined on international markets and are supplied at the import parity price (that is, supply is perfectly elastic).

In countries where there is a combination of biofuel policies in place, it was more challenging to determine the costs and abatement of individual policies. In

1 Since government procurement schemes create a guaranteed demand for biofuels, they are conceptually the same as a quota for biofuel consumption.

particular, where fuel content mandates are used in conjunction with production subsidies, careful consideration must be given to the extent to which each policy leads to abatement in addition to that achieved by other policies. In these cases, cost and abatement were quantified by taking a whole-of-market approach — where the combined impacts of policies were examined, rather than quantifying the impacts of each policy in isolation (box 5.2).

Box 5.2 **Accounting for policy overlaps**

In four study countries a combination of overlapping policies are used to support the consumption of biofuels. This overlap can affect the approach taken to estimate resource costs and abatement, particularly where a fuel content mandate is utilised in conjunction with other policies.

Under a binding fuel content mandate, the volume of biofuel consumed in a country is set by the mandate, meaning that other policies will generally not affect the overall level of consumption of biofuel. Where this occurs, other policies can represent a transfer to producers (both domestic and foreign depending on the eligibility requirements for the subsidy) and may also increase the level of domestic biofuel production relative to imported biofuels (where the mandate is met by a mix of imported and domestic production). Where a subsidy shifts consumption towards higher cost domestic producers and away from imported biofuel, this will also lead to additional resource costs.

Where a fuel content mandate does not bind, other policies are inducing additional consumption of biofuels rather than the mandate. In this case, the total subsidy equivalent is estimated taking into account the costs of these policies.

Estimating abatement

The abatement attributed to a policy is determined by estimating the amount of greenhouse gas emissions that occur in the year of analysis (with the policy) relative to that which would have occurred without the policy (counterfactual emissions). In order to determine counterfactual emissions, assumptions must be made about the mix of fuels that would have been consumed if the policy had not been introduced and their emissions intensity. It is difficult to estimate with any precision the volume of biofuels and conventional fuels consumed in the 'counterfactual' (for example, due to uncertainty about whether any biofuel producers would be competitive in the absence of government assistance, or because data are not available). Consequently, the default assumption adopted for each country is that no biofuel would be consumed under the counterfactual scenario (box 5.3).

Box 5.3 **Consumption of biofuels without government assistance**

The costs of producing biofuel vary by country or region and depend on a range of factors including the type of feedstock used and the technology used to convert the feedstock into fuel. In most parts of the world (with Brazil being a notable exception), biofuels cost significantly more to produce than conventional petroleum-derived fuels (IEA 2006b). Consequently, consumption and production of biofuel 'has been, and continues to be shaped profoundly by government policies' (Steenblik 2007, p. 3).

In recent years, increasing oil prices combined with lower biofuel production costs have improved the cost competitiveness of biofuels with conventional fuels. However, in most countries biofuels are still not competitive with petrol and diesel without subsidies (IEA 2006b). This is partly because it is not just the oil price that matters — the opportunity cost of the feedstock is also a critical factor, and thus as feedstock prices rise the cost competiveness of biofuel is reduced.

Nevertheless, it is impossible to definitively conclude that there would be no consumption of ethanol or biodiesel in the study countries without government support. There are several reasons why this may not be the case:

- Biofuel might be used as a fuel additive, for specific purposes.
- Some consumers may be willing to pay a premium for biofuels.
- Some biofuel producers may be able to compete with suppliers of petrol or diesel when their production costs are low (for example, by producing biodiesel from recycled cooking oil) or when conventional fuel prices are high (for example, due to high world oil prices).

The potential for biofuel consumption in the absence of policy support was considered in all study countries. While it was not possible to definitively conclude either way, in most countries it appears unlikely that biofuels would be consumed at any significant level without government assistance (with the United States being one possible exception).

In some parts of the United States, ethanol is added to petrol as an oxygenate to meet air quality regulations (by reducing emissions of particulates and toxic chemicals). While ethanol is not the only chemical to be added for this purpose, it is the most commonly used. Consequently, sensitivity analysis was conducted for the United States to take into account ethanol used to meet air quality regulations in the regions where these regulations are in place. Where there is consumption of biofuel in the counterfactual scenario, this affects the level of abatement and cost attributed to a given policy, but not the implicit abatement subsidy (average cost).

Sources: IEA (2006b); Steenblik (2007).

The Commission has used life-cycle emissions intensity estimates of different fuels in its analysis, as there can be significant differences in the emissions generated during the production and distribution of fuels. In particular, life-cycle emissions can differ significantly depending on the type of feedstock used (appendix M). For

each country, an average abatement factor is estimated that takes into account the mix of feedstocks used. This indicates the average amount of life-cycle emissions per litre of biofuel consumed.

Using the average abatement factors, abatement estimates were calculated for specific policies where it was possible to separate out the impacts of a policy on biofuel consumption. In addition, 'whole of market' abatement is estimated for ethanol and biodiesel in each country. This was done by estimating how much abatement is achieved by all policy measures for each biofuel type.

A detailed discussion of the approach, assumptions and data used for each country in the biofuels supply-side analysis is provided in appendix N.

Fuel taxes

Fuel taxes — and ETSs that cover fuel — raise the price of fuel and therefore reduce fuel consumption and greenhouse gas emissions from fuel use. Thus, abatement occurs on the demand side of the fuel market. The approach to estimating costs is different to that used for biofuel policies, which focused on supply-side costs and abatement.

For example, in response to higher fuel prices, users of fuel will tend to reduce their consumption by:

- substituting between vehicle types (for example, to more fuel-efficient cars or those that run on a lower-taxed fuel, such as ethanol or LPG) or between modes of transport (for example, greater use of rail)
- travelling less
- re-organising their supply chains and/or the spatial structure of production.

The consumption cost of reduced demand for fuel can be estimated as the net cost to consumers (box 5.4).

Estimating costs

The magnitude of these consumption costs was estimated by comparing observed prices and consumption relative to a counterfactual scenario (an estimate of how much fuel would have been consumed had fuel taxes not been imposed).

Box 5.4 **The economic cost of fuel taxes**

By raising the price of fuel, fuel taxes discourage consumption. Induced reductions in consumption of fuel come at an economic cost. This economic cost is not the amount of tax paid. Rather, it incorporates two kinds of costs (that are more difficult to quantify):

- Loss of the greater enjoyment or utility a consumer would have received using the fuel, for example by driving to work or going on a road trip.
- The costs of switching to different modes of transport (that use less fuel) but may not have the same valued attributes as a consumer's usual car.

Fuel taxes may also increase the amount of money that consumers spend on fuel, which means they must forgo consumption of other goods or services.

These consumption costs can be estimated by quantifying the decrease in 'consumer surplus' (less any transfers to the government through tax revenues) due to the imposition of a fuel tax (appendix O). Consumer surplus is a concept used in economics to measure the welfare effects of price and income changes.

The size of these costs depends on the characteristics of demand — in particular, how consumers respond to increases in fuel prices by reducing the amount of fuel they consume (appendix O). This is measured by the own-price elasticity of demand. The Commission has used low and high elasticity values of -0.25 and -0.75 respectively. (A value of -0.25 means that a one per cent increase in the fuel price leads to a 0.25 per cent reduction in fuel consumption). These values are based on estimates of long-term elasticities in the literature (appendix O). Long-term estimates have been used for this analysis, as they capture longer-term behavioural responses to fuel taxes that have been in place for a considerable period of time in most of the study countries. Long-term estimates also allow for changes in demand that result from investment decisions, such as purchases of lower-emissions (more fuel-efficient) vehicles.

Estimating induced abatement

Abatement due to a fuel tax includes the reduction in greenhouse gas emissions associated with the direct reduction in fuel consumption induced by the tax, as well as any change in emissions (positive or negative) that might occur due to consumers switching to alternative modes of travel. This first element can be estimated using the change in the level of fuel demand (the difference between the counterfactual level and the current observed level of fuel consumption) and estimates of the emissions intensity of fuels. The Commission estimated abatement over a one year period in each country. However, where fuel taxes have been in place for long

periods of time, abatement could be driven by cumulative changes in behaviour over many years.

Quantifying consumers' substitution to non-road modes of transport (supply-side abatement) and estimating the resulting change in emissions is more difficult. This would require a substantial amount of detailed information on the extent to which consumers switch between road and non-road forms of transport as fuel prices rise, as well as estimates of the emissions intensity of other modes of transport. Consequently, abatement could only be estimated on the demand side.

In order to estimate the average consumption cost of fuel taxes in each country, a cost per unit of (demand-side) abatement for fuel taxes was estimated by dividing estimated consumption costs by the estimated level of abatement.

A detailed discussion of the approach, assumptions and data used for each country in the demand-side analysis for road transport is provided in appendix O.

Interpreting the results

In its biofuel analysis, the Commission has estimated:

- a subsidy equivalent for each policy (where possible) and fuel type, and a total subsidy equivalent for each country
- abatement by policy (where possible) and fuel type, and total abatement for each country
- an implicit abatement subsidy for each policy (where possible) and fuel type, and an average implicit abatement subsidy for each country.

In its fuel tax analysis, the Commission has estimated in each study country:

- total consumption costs
- total abatement
- average consumption costs (per tonne of CO_2-e).

These estimates provide some insights into the effects of emissions-reduction policies in the study countries. However, there is no single value that can be used to measure the relative 'effort' of a country in reducing emissions or the impacts of a country's climate change policies on its emissions-intensive trade-exposed industries (chapter 6). The Commission's road transport analysis sheds little light on these issues. However, this analysis does indicate the costs that countries are bearing in order to implement biofuel policies and the potential cost-effectiveness of these policies. Further, it also provides an illustration of the potential abatement and

costs of fuel taxes. However, even then the results are only indicative and must be interpreted carefully.

Total subsidy equivalents, consumption costs and abatement are not particularly meaningful on their own. For example, high levels of abatement could come at great cost due to inefficient policies or could indicate that a country has many low-cost abatement opportunities. Further, the study countries vary significantly in size, levels of total fuel consumption and the mix of fuels used in road transport. In consequence, the results are presented with some contextual information, including total abatement as a percentage of counterfactual emissions and the total subsidy equivalent as a percentage of GDP.

The Commission has not aggregated estimates of costs and abatement for biofuel policies and fuel taxes for each country, as these will not necessarily be representative of abatement costs in the transport sector more broadly. Moreover, the different methodological approaches used to analyse fuel taxes and biofuel policies makes it difficult to directly compare results to provide an aggregate estimate for road transport fuels.

Sensitivity analysis

For some policies sensitivity analysis was conducted — particularly when there were differences across available sets of data — with the results reported in a range around a 'central' estimate. The 'central' estimate is based on the set of assumptions that the Commission considers to be the most accurate given the available data.

5.2 Supply-side results

Cross-country analysis

The Commission's analysis of the supply-side abatement costs of biofuel policies suggests that these policies are a relatively costly means of achieving abatement. In all countries except China, the average implicit abatement subsidy was estimated to be over A$300/t CO_2-e (table 5.2). By way of comparison, this is well above both the permit price of any existing ETS in these countries and the implicit abatement subsidies estimated on the supply side for most electricity generation policies.

Table 5.2 **Average implicit abatement subsidies**
2009, 2010

	Total subsidy equivalent	*Total abatement*	*Average implicit abatement subsidy*
	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Australia	144	0.4	364
China[a]			
Ethanol	1 904	-1.4–0.8	-6 105
Biodiesel	94	0.2	592
Germany	1 711	5.5	310
Japan	57	0.1	617–653
New Zealand	3	0.01	391
South Korea	196	0.2–0.5	415–831
United Kingdom	680	2.0	335
United States	12 470–17 477	19–26	604–672

[a] The average implicit abatement subsidy estimate for China is presented separately for biodiesel and ethanol and only a central estimate for ethanol is given due to the negative abatement result.

Source: Appendix N.

The high average implicit abatement subsidies of biofuel policies reflect both the large estimated total subsidy equivalents of these measures as well as the relatively small amount of abatement they achieve. These findings are broadly in line with those in a series of reports on assistance to biofuels by the Global Subsidies Initiative (box 5.5).

The outlier among the eight study countries is China. There is considerable uncertainty about the life-cycle emissions of ethanol in China (with abatement due to ethanol policies presented as a range from -1.4 Mt to +0.8 Mt CO_2-e) (table 5.2). It is important to note that the negative estimate of the implicit abatement subsidy for ethanol (-A$6105/t CO_2-e) is due to negative abatement — that is, induced *additional* emissions — not negative costs. While significant costs are incurred, the use of ethanol (as a replacement for petrol) is likely to increase emissions for reasons explained below (although there is significant uncertainty surrounding the estimates). At nearly A$2 billion, China's total subsidy equivalent (which comprises subsidy equivalents of A$1904 million for ethanol and A$94 million for biodiesel) is the second highest among study countries. Although this cost is small as a proportion of GDP (0.03 per cent) it is high when expressed as a unit cost (A$1.15 per litre of petrol equivalent of ethanol consumed in China) (table 5.3).

Box 5.5 **Global subsidies initiative studies into government support for biofuel**

The Global Subsidies Initiative (GSI) produced a series of reports over 2006 to 2010 addressing government support to biofuels in different countries, including Australia, China and the United States. The GSI reports identify and quantify subsidies to biofuel production, distribution and consumption as well as subsidies to producers of key inputs into biofuel production. In estimating total assistance to ethanol and biodiesel, the GSI studies have incorporated the costs of a broader range of policies than the Commission's analysis, including subsidies to agricultural producers, import tariffs and research and development funding.

The GSI's estimates differ from the Commission's primarily due to differing years of analysis (consumption of biofuel has increased and there have been changes in the number of policies and the design of specific policies since the GSI conducted its analysis) and also because the GSI included a broader range of policies in its analysis. Another key difference is that the GSI often presents abatement estimates by feedstock, whereas the Commission's results represent an average across the mix of feedstocks used in a country.

Global Subsidies Initiative estimates for ethanol

Country	*Year*	*Total assistance (millions)*	*Assistance per litre*	*Assistance per tonne of CO_2-e*[a]
Australia	2006-07	A$36.2	A$0.42	A$380 – A$790
China	2006	US$114	ne	ne
European Union	2008	€841	€0.24	€669 – €1 422
United States	2006	US$5 123 – US$6 782	US$3.97 – US$5.22	US$520

[a] Assistance per tonne of CO_2-e abated is estimated by feedstock and presented as a range across the different feedstocks used in a given country. These figures are not average assistance per tonne of CO_2-e abated like the Commission's implicit abatement subsidies. **ne** Not estimated.

Sources: GSI (2006; 2008a; 2008b; 2010)

The average implicit abatement subsidy for Australia was estimated to be around A$364/t CO_2-e. This is similar to the estimates for New Zealand, Germany and the United Kingdom. While Germany and the United Kingdom have the lowest average costs, the volume of biofuels consumed in these countries is the highest, as are the total subsidy equivalents as a percentage of GDP. In the United States, Japan and South Korea, the average implicit abatement subsidies are relatively high. This result for the United States is mainly due to a number of policy measures that have substantial subsidy equivalents but may not be contributing substantially to abatement.

There can be significant variation in the estimated costs and abatement of biofuel measures in each country, depending on the data and assumptions used

There can be significant variation in the estimated costs and abatement of biofuel measures in each country, depending on the data and assumptions used (appendix N). In order to interpret estimates of average implicit abatement subsidies, it is important to also consider total subsidy equivalents and abatement by country.

Total costs

The total resource cost of biofuel policies in each country, measured as the total subsidy equivalent, varies widely (table 5.3). This is due to differences in the amounts of biofuel that each country consumes, and differences in the level of government assistance provided per litre of biofuel consumed (measured as the production subsidy equivalent per litre of petrol equivalent).

At A$144 million, the total subsidy equivalent of Australia's biofuel policies is the third lowest of the eight study countries. This figure reflects a relatively low level of consumption (275 ML petrol equivalent in 2009-10) and a moderate production subsidy equivalent (A$0.52/L petrol equivalent). However, as a proportion of GDP, the estimated total subsidy equivalent in Australia (0.01 per cent of GDP) is the fourth highest of the study countries.

Biofuel policies in the United States have the highest estimated cost (in absolute terms and as a percentage of GDP) of all the study countries: A$17.5 billion in the central estimate (0.11 per cent of GDP), which is higher than the other countries combined. This reflects that the United States consumes the largest amount of biofuel (29 273 ML petrol equivalent in 2009) and that there is considerable government support for biofuel consumption. The implicit abatement subsidy is also high, since the production subsidy equivalents (A$0.57/L petrol equivalent for ethanol and A$1.12/L petrol equivalent for biodiesel) are relatively high.

Abatement

Total abatement was estimated by multiplying the amount of policy-induced biofuel consumption by an average abatement factor, which reflects the abatement per unit of biofuel (table 5.4). Total abatement ranged from 0.01 Mt CO_2-e (New Zealand) to 26 Mt CO_2-e (the central estimate for the United States).

Table 5.3 **Estimates of total subsidy equivalents**
2009, 2010

	Total biofuel consumption	*Average production subsidy equivalent*	*GDP*	*Total subsidy equivalent*	*Total subsidy equivalent as a percentage of GDP*
	ML petrol equivalent	A$/L petrol equivalent	A$b (2010)	A$m (2010)	%
Australia	275	0.52	1 343	144	0.01
China	1 731	1.15	6 402[a]	1 998	0.03
Germany	3 775	0.45	3 572	1 711	0.05
Japan	57	1.00	5 959	57	0.001
New Zealand	6	0.56	152	3	0.002
South Korea	401	0.49	1 101	196	0.002
United Kingdom	1 419	0.48	2 437	680	0.03
United States	29 273	0.54–0.62	15 936	12 470–17 477	0.08–0.11

Source: Appendix N.

For Australia, total abatement from biofuel policies was estimated at 0.4 Mt CO_2-e (an estimated reduction of 0.6 per cent from the counterfactual where there are no biofuel policies). However, the estimated reduction in greenhouse gas emissions from biofuel policies was small for all countries relative to the counterfactual level of road transport emissions. Only in Germany, the United Kingdom and the United States was abatement due to biofuel policies higher than one per cent of counterfactual emissions.

China's abatement from ethanol use was estimated to be above that of Australia at the high end, and negative at the low end. This reflects a very low (and potentially negative) average abatement factor for ethanol. Together with the high unit cost estimated, this explains the high cost of China's ethanol policies in terms of reducing emissions.

In most study countries, greater abatement per litre is achieved through policies that increase the proportion of biodiesel in the fuel mix (relative to ethanol). For example, in Australia, the average abatement factor for biodiesel (2218 g CO_2-e/L petrol equivalent) is significantly larger than that for ethanol (1081 g CO_2-e/L petrol equivalent) (table 5.5). The only country where ethanol achieves, on average, greater abatement per litre than biodiesel is Germany (which has the largest consumption of biodiesel of all study countries).

Table 5.4 **Estimates of policy-induced abatement**
2009, 2010

	Total road transport sector emissions	*Total abatement*	*Total abatement as a percentage of counterfactual road transport emissions*
	Mt CO_2-e	Mt CO_2-e	%
Australia	69	0.4	0.6
China[a]	334		
Ethanol	..	-1.4 to +0.8	-0.4 to +0.2
Biodiesel	..	0.2	0.05
Germany	146	5.5	4
Japan	208	0.1	0.04
New Zealand	13	0.01	0.06
South Korea	79	0.2–0.5	0.3–0.6
United Kingdom	119	2.0	1.7
United States	1 537	19–26	1.2–1.7

a Abatement for China is presented separately for ethanol and biodiesel due to the negative abatement result for ethanol.

Source: Appendix N.

The Commission has also estimated the abatement induced by biofuel policies on the demand side. This can occur when biofuel policies lead to higher fuel prices, although the abatement that results is generally much smaller than the abatement that occurs on the supply side. However, both the costs and abatement on the demand side are estimated to be relatively small (box 5.6)

Table 5.5 **Average abatement factors by country**
Central estimates

	Average abatement factor	
Country	*Ethanol*	*Biodiesel*
	g CO_2-e/L petrol equivalent	g CO_2-e/L petrol equivalent
Australia	1 081	2 218
China	-224	464
Germany[a]	1 593	1 416
Japan	1 576	..
New Zealand	1 277	2 033
South Korea	..	771
United Kingdom	1 594	1 442
United States	832	2 318

a In addition, an average abatement factor of 1691 g CO_2-e/L (petrol equivalent) was used for the analysis of vegetable oil in Germany. **..** Not applicable.

Source: Appendix N.

Box 5.6 **Demand-side abatement from biofuel policies**

The Commission sought to estimate the abatement induced by biofuel policies on the demand side. This can occur when biofuel policies lead to higher fuel prices, although the abatement that results is generally much smaller than the abatement that occurs on the supply side.

Illustrative estimates were calculated using the same approach used for fuel taxes, where the 'tax' or price increase is a measure of the cost that some biofuel policies can impose on consumers of transport fuels. For example, fuel suppliers may pass on the cost of meeting a fuel content mandate to consumers in the form of higher prices, which reduces demand and can induce some abatement.

Specifically, the subsidy equivalent was divided by the volume of fuel that is affected. This was done only for policies where the costs are borne by consumers rather than by governments (such as fuel content mandates). As a result, estimates were calculated only for Germany, the United Kingdom and the United States (the results are provided in Appendix O).

In all cases, the estimated total consumption cost and abatement attributable to demand-side impacts of biofuel policies are smaller than the corresponding values for the supply side. This is largely because the estimated impact on fuel prices is small (given the large volume of petrol and diesel that are consumed in most countries relative to biofuels) — approximately A$0.01/L to A$0.02/L in each country. The average cost of demand-side abatement is also relatively low in all three countries, ranging from less than A$1/t CO_2-e (for biodiesel in the United States) to A$5/t CO_2-e (for both ethanol and biodiesel in Germany).

Source: Appendix O.

Australia

Australia provides significant support to biofuel — both ethanol and biodiesel — through production subsidies. These involve payments to biofuel producers that offset the amount of fuel excise that they pay. The analysis did not include the New South Wales biofuels mandate because, during the year of analysis, the minimum sales percentages required under the Act were not enforced due to domestic supply constraints (Office of Biofuels, NSW Land and Property Management Authority, pers. comm., 15 April 2011). Hence, this mandate is not likely to have induced a significant amount of biofuel consumption in addition to the production subsidies.

Australia's biofuel policies are estimated to achieve total abatement of 0.4 Mt CO_2-e (0.6 per cent of counterfactual road transport emissions) at a total subsidy equivalent of A$144 million (table 5.6). This incorporates A$108 million for support to ethanol producers through the Ethanol Production Grants program,

and A$35 million for support to biodiesel producers through the Cleaner Fuel Grants Scheme.

Support to ethanol producers was appreciably higher than support to biodiesel producers as the volume of ethanol consumed (275 ML) was considerably higher than the volume of biodiesel consumed (90 ML). However, the Ethanol Production Grants program did not generate significantly more abatement than the Cleaner Fuel Grants Scheme. This was because the average abatement for a given quantity of biodiesel was higher than that for ethanol.

The implicit abatement subsidies of the individual policies reflect these differences in average abatement. The implicit abatement subsidies for the Ethanol Production Grants program and the Cleaner Fuel Grants Scheme were A$532/t CO_2-e and A$186/t CO_2-e respectively.

However, the biofuel production subsidies are to be gradually reduced as effective tax rates are gradually increased from December 2011. The changes are likely to significantly alter the costs and abatement associated with these policies (although the changes do not affect the Commission's estimates, which are estimated for the 2009-10 financial year).

Table 5.6 **Biofuel policies, Australia**
July 2009 – June 2010

Policy	*Type*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
		A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Ethanol Production Grants	Production subsidy	108	0.2	532
Cleaner Fuel Grants Scheme	Production subsidy	35	0.2	186
Total		**144**	**0.4**	**364**
Abatement (%)[a]		..	0.6	..

[a] Abatement as a percentage of counterfactual emissions from road transport. **..** Not applicable.

Source: Appendix N.

China

The Chinese government provides significant financial and regulatory support for domestic ethanol producers. All ethanol produced and consumed in China is sourced from five authorised producers (which are majority state-owned). In contrast, biodiesel plants tend to be small, privately owned enterprises and are more numerous and geographically dispersed than ethanol plants.

Differences in the level of support for ethanol and biodiesel are reflected in the subsidy equivalents shown in table 5.7. Total support for ethanol (A$1.96 billion) dwarfs that for biodiesel (A$94 million). However, the abatement attributable to ethanol policies does not reflect the level of support provided, with the results suggesting ethanol policies actually increased emissions by 312 kt CO_2-e in 2009 (using the central estimate). In contrast, abatement due to biodiesel policies was estimated to be 158 kt CO_2-e.

Abatement estimates for ethanol policies in China must be interpreted with care. Taking into account the mix of feedstocks used, ethanol appears to have, on average, higher life-cycle emissions intensity than petrol. This suggests that any policy that increases the share of ethanol in total fuel consumption relative to petrol *increases* total greenhouse gas emissions.

The drivers of this result are the estimates for life-cycle emissions intensity for ethanol produced using maize and wheat, which are higher than those used for other countries (maize and wheat ethanol represent 90 per cent of all ethanol produced in China). This is likely to be due to high fertiliser application rates during the production of the feedstock and the relatively high level of energy that is used to refine feedstocks into fuel in China (Ou et al. 2009).

However, estimated abatement is highly sensitive to the life-cycle assessment method used and assumptions regarding the inclusion of land-use change or the treatment of recycled or waste feedstocks (appendix M). Recognising this uncertainty, sensitivity analysis was undertaken. This suggests that abatement from ethanol policies could range from -1.4 to +0.8 Mt CO_2-e.

The implicit abatement subsidy for ethanol is estimated to be -$A6105/t CO_2-e (for the central estimate) and A$592/t CO_2-e for biodiesel. The high costs and small negative central estimate for abatement from ethanol policies are the principal reason the implicit abatement subsidy for ethanol is so large and negative. It suggests that these policies are effectively acting as a substantial subsidy for emitting rather than for abating.

Table 5.7 **Biofuel policies, China**
2009

Policy	*Type*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
		A$m (2010)	Mt CO_2-e[a]	A$/t CO_2-e[a]
Tax incentives	Production subsidy	744	..	..
Flexible subsidies for loss	Production subsidy	640	..	..
National Scheme of Extensive Pilot Projects on Bioethanol Gasoline for Automobiles	Guaranteed market and production subsidy	614	..	..
Totals				
Ethanol	..	1 904	-1.4 to +0.8	-6 105[b]
Biodiesel	..	94	0.2	592
Abatement (%)[c]	Ethanol	..	-0.4 to +0.2	..
	Biodiesel		0.05	

[a] Due to the policy overlaps it was not possible to estimate abatement and implicit abatement subsidies for each ethanol policy separately. [b] The implicit abatement subsidy for ethanol is presented for the central estimate only due to the negative estimate of abatement [c] Abatement as a percentage of counterfactual emissions from road transport. **..** Not applicable.

Source: Appendix N.

Germany

A large domestic market for biofuels exists in Germany, accounting for 5.8 per cent of all road transport fuel sold in 2009. This market is underpinned by fuel tax exemptions and mandates covering ethanol, biodiesel and vegetable oil used directly as a fuel for road transport.

There is significant overlap between the fuel tax exemptions and the mandates. Evidence suggests that the tax exemptions are driving consumption of biodiesel and vegetable oil, as the mandate did not bind for these fuels in 2009. However, the mandate did lead to incremental consumption of ethanol and was found to bind in 2009. Consequently, the tax exemptions are unlikely to have led to additional consumption of ethanol, in part because only a small proportion is eligible for tax relief (less than three per cent).

Due to this overlap, the Commission has not estimated costs and abatement for each policy individually, presenting subsidy equivalents, abatement and implicit abatement subsidies for each of the three fuel types and for all three fuel types combined.

In combination, the tax exemptions and mandates imposed significant costs — the total subsidy equivalent for Germany was estimated at A$1.7 billion. Support for biodiesel accounted for the largest share of this with a subsidy equivalent of A$1.1 billion (table 5.8).

Total abatement due to Germany's biofuel policies was estimated at 5.5 Mt CO_2-e, or 3.6 per cent of counterfactual emissions in the road transport sector. The Energy Tax exemption is likely to account for the majority of the abatement (and cost) as it is the main support measure for biodiesel and vegetable oil which together account for more than three quarters of total abatement.

The implicit abatement subsidy for the policies combined is estimated at A$310/t CO_2-e. Of the individual fuels, the cost of abatement was highest for ethanol, with an implicit abatement subsidy of A$444/t CO_2-e, followed by biodiesel and then vegetable oil with implicit abatement subsidies of A$275 and A$242/t CO_2-e respectively.

Table 5.8 **Whole of market estimates, Germany**
2009

Fuel type	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Ethanol	533	1	444
Biodiesel	1 130	4	275
Vegetable oil	48	0.2	242
All fuels	**1 711**	**6**	**310**
Abatement (%)[a]	..	4	..

[a] Abatement as a percentage of counterfactual emissions from road transport. **..** Not applicable.

Source: Appendix N.

Japan

Japan consumes only a small quantity of ethanol (0.1 per cent of petrol) and a negligible quantity of biodiesel. Consequently, only one biofuel policy was analysed — an exemption from fuel taxes for ethanol. A tax exemption for biodiesel was also considered for analysis in Japan, but eliminated on the grounds of both immateriality and insufficient information.

The ethanol tax exemption in Japan is still small in scale relative to policies in other countries. The subsidy equivalent for the policy was estimated at A$57 million.

Total abatement was also low, at between 87–92 kt CO_2-e, or around 0.04 per cent of counterfactual emissions from the road transport sector (table 5.9). Abatement is expressed as a range due to uncertainty about the share of ethanol produced from different feedstocks and the method of feedstock cultivation (both factors affect the emissions intensity of ethanol production). While this uncertainty does not lead to a wide abatement range, it does have a significant impact on the range of the implicit abatement subsidy. The implicit abatement subsidy for Japan is estimated at between A$617–A$653/t CO_2-e.

Table 5.9 **Ethanol fuel tax exemption, Japan**
April 2009 – March 2010

Fuel type	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Ethanol	57	0.087–0.092	617–653
Abatement (%)[a]	..	0.042–0.044	..

[a] Abatement as a percentage of counterfactual emissions from road transport. **..** Not applicable.

Source: Appendix N.

New Zealand

Demand for biofuel in New Zealand is driven by a tax exemption for ethanol and a production subsidy for domestic biodiesel producers. The estimates of the total subsidy equivalent (A$3 million) and abatement (8 kt CO_2-e) for these policies is very low in comparison to other countries, reflecting low levels of consumption. Total consumption of biofuels in 2010 was just 5.6 ML (petrol equivalent). Most of the cost and abatement was attributable to the ethanol tax exemption, with ethanol accounting for around 80 per cent of all biofuel consumed.

The average implicit abatement subsidy for New Zealand was estimated at A$391/t CO_2-e. The implicit abatement subsidy is A$479/t CO_2-e for ethanol compared to A$163/t CO_2-e for biodiesel (table 5.10). These figures are in line with the results for comparable policies in Australia. As was the case in Australia, the estimates suggest that the cost of abatement for biodiesel policies is significantly lower than for ethanol policies, mainly reflecting higher average abatement per litre consumed.

Table 5.10 **Biofuel policies, New Zealand**
2010

Policy	*Type*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
		A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Ethanol fuel tax exemptions	Tax exemption	2.7	0.006	479
Biodiesel Grants Scheme	Production subsidy	0.4	0.002	163
Total		**3.1**	**0.008**	**391**
Abatement (%)[a]		..	0.06	..

[a] Abatement as a percentage of counterfactual emissions from road transport. **..** Not applicable.

Source: Appendix N.

South Korea

South Korea is alone among the study countries in providing support only to biodiesel and not to ethanol. The absence of policy support for ethanol may reflect the relatively low proportion of petrol consumed in South Korea — petrol accounts for just 30 per cent of road transport fuel consumed (appendix M).

The main source of government support for biodiesel is through a rebate of fuel tax. The subsidy equivalent for this policy was estimated to be A$196 million and abatement at 0.2–0.5 Mt CO_2-e during 2010 (table 5.11). Abatement is estimated as a range due to significant uncertainty with regard to the emissions intensity of biodiesel consumed. Abatement due to the policy is equivalent to between 0.3 to 0.6 per cent of counterfactual road transport greenhouse gas emissions.

The implicit abatement subsidy due to the tax rebate was estimated at between A$415–A$831/t CO_2-e. At the high end of this range, this is a larger subsidy per tonne of abatement than any other study country.

Table 5.11 **Biodiesel tax rebate, South Korea**
2010

Fuel type	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Biodiesel	196	0.2–0.5	415–831
Abatement (%)[a]	..	0.3–0.6	..

[a] Abatement as a percentage of counterfactual emissions from road transport. **..** Not applicable.

Source: Appendix N.

United Kingdom

The United Kingdom provides support to biofuel producers by mandating the amount of biofuel consumed each year (as a percentage of total fuel consumption) through the Renewable Transport Fuels Obligation. The total subsidy equivalent for the Renewable Transport Fuels Obligation was estimated at A$680 million in fiscal year 2009 (April 2009 to March 2010) (table 5.12). Thus, while there is no budgeted government expenditure for support to the biofuel industry, government support for biofuels through regulation involves significant resource costs.

Table 5.12 **Renewable Transport Fuels Obligation, United Kingdom**
April 2009 – March 2010

Fuel type	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Ethanol	214	0.5	424
Biodiesel	465	1.5	305
All fuels	**680**	**2.0**	**335**
Abatement (%)[a]	..	1.7	..

[a] Abatement as a percentage of counterfactual emissions from road transport. **..** Not applicable.

Source: Appendix N.

The average implicit abatement subsidy was estimated at A$335/t CO_2-e, with around 2 Mt CO_2-e abated as a result of the Renewable Transport Fuels Obligation in 2009. This level of abatement is small relative to the counterfactual road transport sector emissions, representing approximately 1.7 per cent of total emissions from road transport in the United Kingdom (that said, abatement as a proportion of counterfactual emissions is larger than in many other study countries).

The implicit abatement subsidies by fuel type suggest that while ethanol achieved greater abatement for each additional litre of ethanol induced, it did so at a higher cost — with the implicit abatement subsidies for ethanol and biodiesel estimated to be A$424/t CO_2-e and A$305/t CO_2-e respectively.

United States

A large volume of biofuel — mostly ethanol produced from maize — is consumed each year in the United States. There is considerable government support for biofuel consumption, consisting of subsidies for domestic producers, concessional rates of fuel excise, fuel content mandates, government procurement regulations and an import tariff.

The total subsidy equivalent of biofuel policies in the United States was estimated at A$17.5 billion in US fiscal year 2009 (October 2008 to September 2009), most of which can be attributed to support for ethanol (A$16.1 billion) (table 5.13).

Table 5.13 **Total subsidy equivalent, United States**
October 2008 – September 2009

		Subsidy equivalent		
Policy	*Level of government*	*Ethanol*	*Biodiesel*	*Total*
		A$m (2010)	A$m (2010)	A$m (2010)
Alcohol and Biodiesel Fuel Credits	National	5 718	922	6 640
Bioenergy Program for Advanced Biofuels	National	8	7	15
State-level excise concessions for ethanol	Sub-national	3 029	0	3 029
Renewable Fuel Standard[a]	National	7 321	472	7 793
Federal Fleet Management Guidance	National	1	0	0.8
Total	**..**	**16 076**	**1 401**	**17 477**

[a] The central estimate of the subsidy equivalent is reported for the Renewable Fuel Standard. This includes the impact of the tariff on most ethanol imports. **..** Not applicable.

Source: Appendix N.

Abatement from these policies was estimated to be around 19–26 Mt CO_2-e, which was equivalent to 1.2–1.7 per cent of road transport emissions in the counterfactual scenario (where there is no policy support for biofuels). This translates to an average implicit abatement subsidy of around A$604–672/t CO_2-e (table 5.14).

These estimates were calculated using a 'whole of market' approach (for each of ethanol and biodiesel), due to significant overlaps between policy measures. Accordingly, the total subsidy equivalent was calculated by adding up the subsidy (explicit or implicit) that each US policy provided for the consumption of biofuel.

Table 5.14 **Whole of market estimates, United States**
October 2008 – September 2009

Fuel type	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Ethanol	11 337–16 076	16–23	617–724
Biodiesel	1 133–1 439	3	389–494
All fuels	**12 470–17 477**	**19–26**	**604–672**
Abatement (%)[a]	..	1.2–1.7	..

[a] Abatement as a percentage of counterfactual emissions from road transport. **..** Not applicable.

Source: Appendix N.

The amount of biofuel consumed in fiscal year 2009 was determined by the mandates in the Renewable Fuel Standard. However, ethanol and biodiesel that were used to meet this mandate could also benefit from production subsidies, excise concessions or import tariffs. While these other policies do not affect the total amount of biofuel consumed, they would be expected to increase the level of domestic production at the expense of imports. This can increase the cost of biofuels (by favouring higher-cost domestic production over lower-cost imports) and can affect the level of abatement (by changing the types of feedstocks that are used).

The range of results presented reflects different assumptions about the counterfactual level of biofuel consumption and the effect of differing wholesale prices of fuel (which were used to calculate the subsidy equivalent of the Renewable Fuel Standard). The counterfactual assumption was changed from the default (of zero consumption) to illustrate a possible alternative in which around one third of ethanol would have been consumed in the absence of biofuel policies. This is because some ethanol is specifically added to petrol in some parts of the United States to meet air quality regulations (by reducing emissions of particulates and toxic chemicals)[2], and estimates of the volume used for this purpose have been published.

[2] Other chemicals can be added to fuels for this purpose, although some of these have been banned in parts of the United States. While it is possible that ethanol could be used in this way in other countries in the absence of policy support, estimates of the amount that would be used were not available.

5.3 Demand-side results

This section provides illustrative estimates of the cost and abatement from fuel taxes in each study country. It is important to note that this analysis estimates the abatement achieved due to the full amount of fuel tax applied in each country. Further, abatement is estimated relative to a counterfactual scenario in which there are no fuel taxes (and fuel has never been taxed). Estimated abatement does not take into account the other reasons that countries impose fuel taxes and is accordingly greatly biased upwards, as well as being very high for each country.

There are large differences in fuel tax rates across countries (table 5.15), reflected in the significant variation in estimated consumption costs and abatement (table 5.16). Countries that have higher average fuel taxes also have higher average consumption costs per tonne of CO_2-e, because higher tax rates induce a larger reduction in fuel demand, which becomes increasingly more costly the larger the reduction (all else equal). Correspondingly, the effect on consumers is larger and consumers may make bigger changes to their behaviour.

Table 5.15 **Fuel tax rates and volumes consumed[a,b]**

		Petrol		*Diesel*		*LPG*	
Country	*Year*	*rate*	*volume*	*rate*	*volume*	*rate*	*volume*
		A$/L	ML	A$/L	ML	A$/L	ML
United States[c]	2009	0.11	504 844	0.12	132 717	0.10	1 022
China	2010	0.16	81 554	0.13	82 989	..	na
Australia	2009-10	0.38	16 619	0.38	18 053	..	2 083
New Zealand	2010	0.45	2 505	0.0029	2 161	0.08	208
Japan	2009[d]	0.67	54 795	0.40	2 830	0.12	2 701
South Korea	2009	0.70	10 132	0.49	15 855	0.21	7 782
Germany	2009	0.94	25 562	0.67	31 174	0.14	942
United Kingdom	2010	0.96	19 982	0.96	24 678	0.27	195

a Only fuel-specific volumetric taxes that are levied directly on vehicle fuels are shown. Note that in some countries other taxes, such as road-user charges, may be levied differently (for example, diesel fuel in New Zealand). **b** Tax rates have been converted to 2010 Australian dollars and are rounded to two significant figures. **c** Tax rates for the United States include both federal and state taxes. **d** Figures for Japan are for April 2009 to March 2010 (the Japanese fiscal year). **..** Not applicable. **na** Not available.

Source: Appendix O.

China and the United States have the lowest fuel taxes of the study countries. While the total consumption costs in these countries are high relative to others, they are low in comparison to the size of each economy (around 0.01–0.02 per cent of GDP in China and 0.01–0.03 per cent of GDP in the United States). Likewise, while the absolute level of abatement is relatively high in both countries, when expressed as a

percentage of estimated road transport emissions in the absence of fuel taxes, it is at the bottom of the range.

Overall, the United States has the lowest average consumption costs, at A$19/t CO_2-e. The average consumption cost in China was estimated to be slightly higher, at A$20–A$23/t CO_2-e. This suggests that the cost of reducing a relatively small proportion of emissions in these countries may be lower than in other countries.

On the other hand, the United Kingdom has the highest average fuel taxes, followed by Germany, Japan and South Korea. In these countries total consumption costs and abatement are both high. Costs range from around 0.10 per cent to 0.33 per cent of GDP in Germany, and from 0.14 per cent to 0.46 per cent of GDP in the United Kingdom. The results also suggest that fuel taxes may have reduced emissions by around 20 to 40 per cent from counterfactual levels in both countries.

However, the average cost of this abatement — in excess of A$100/t CO_2-e in Germany, the United Kingdom and Japan — is considerably higher than for other study countries. This suggests that, at relatively high tax rates, there can be significant costs incurred reducing an additional tonne of emissions. This suggests that the marginal cost of reducing emissions becomes higher as more emissions are abated (in other words, abatement may be cheaper per tonne at lower levels of the fuel tax than are presently in place).

By contrast, the estimates for Australia and New Zealand (including the ETS in New Zealand as well as fuel excise) appear to lie in the middle of the range of countries. The results suggest that fuel taxes may have reduced emissions from road transport by around 8 to 23 per cent in Australia, and 7 to 19 per cent in New Zealand, relative to the counterfactual. For Australia, this could cost up to A$1.2 billion (0.09 per cent of GDP) each year. As a result, the average cost of abatement is around A$57–A$59/t CO_2-e in Australia, and somewhat higher in New Zealand, at A$71–A$73/t CO_2-e.

Furthermore, the estimated cost of demand-side abatement from fuel taxes (per tonne of CO_2-e) is significantly lower in most countries than the cost of supply-side abatement from biofuel policies. This reflects the broader base of fuel taxes — which cover almost all road transport fuels — and the close link between fuel consumption and emissions (although fuel taxes are also used to reduce fuel consumption to target other objectives, such as reducing congestion or urban air pollution). However, fuel taxes are generally not based on the emissions content of each fuel.

Table 5.16 **Fuel taxes**[a]

Range of estimates

Country	*Average fuel tax*[b]	*Consumption cost*	*Consumption costs as a percentage of GDP*[c]	*Abatement*	*Abatement as a percentage of counterfactual road transport sector emissions*	*Average consumption cost*[d]
	A$/L	A$m (2010)	% GDP	Mt CO_2-e	%[e]	A$/t CO_2-e
Australia	0.36	373–1 189	0.03–0.09	6–21	8–23	57–59
China	0.14	449–1 383	0.01–0.02	20–68	6–17	20–23
Germany	0.78	3 437–11 492	0.10–0.33	29–102	17–41	113–119
Japan	0.64	2 238–7 301	0.04–0.13	21–73	9–26	100–105
New Zealand	0.43	54–174	0.04–0.11	1–3	7–19	71–73
South Korea	0.50	1 046–3 432	0.10–0.33	12–41	13–34	83–87
United Kingdom	0.96	3 323–11 125	0.14–0.46	24–85	17–42	130–139
United States	0.11	1 749–5 421	0.01–0.03	92–291	6–16	19

[a] Values are national aggregates over petrol, diesel and LPG. [b] Average per-litre tax, in Australian dollars, over petrol, diesel and LPG (in the year of analysis), and weighted by the taxed volume of each fuel type. Averages for Australia and China are over petrol and diesel only as LPG is not taxed. Average for New Zealand is over petrol and LPG only as diesel use is mainly taxed through vehicle charges. [c] In each case, the lower figure reported for average consumption cost corresponds with the higher value of fuel-demand elasticity used (-0.75), and vice versa. [d] GDP data are from IMF (2011) and were converted to 2010 Australian dollars. [e] Abatement as a percentage of the level of counterfactual emissions in the road transport sector (that is, estimated emissions in the absence of fuel taxes). Emissions data are from IEA (2010a) for China and Korea, and the UNFCCC (2011a) for all other countries. Figures for 2008 were used as this was the latest year for which consistent data were available for the road transport sector.

Sources: IMF (2011); IEA (2010a); UNFCCC (2011a); Appendix N.

6 Conclusions and implications

Key points

- The resources committed by different study countries to emissions-reduction policies vary as a proportion of GDP.
  - In electricity generation, Germany made the largest relative resource commitment, the United Kingdom was next and Australia, along with China and the United States, were in the middle.
  - In biofuels, the US resource commitment was substantially higher than other study countries, though Germany also devoted considerable resources to this abatement policy.
- The cost effectiveness of these actions in achieving abatement, and the amount of abatement actually achieved, also varies widely, both across programs within each country and in aggregate across countries.
  - Explicit carbon pricing in the United Kingdom appears to have been a cost-effective way of achieving considerable abatement.
  - At the other end of the scale, policies to encourage small-scale renewable generation are substantially less cost effective and have led to relatively little abatement.
- The impacts of supply-side policies on product prices appear to have been modest for most countries, with the notable exception of electricity prices in Germany and the United Kingdom, where impacts of over 10 per cent are estimated to have occurred.
- The relative cost effectiveness of a price-based approach is illustrated for Australia by stylised modelling that suggests that the abatement from existing policies could have been achieved at a fraction of the cost.
- However, the estimates in this report cannot be used to determine the appropriate starting price of a broadly-based carbon pricing scheme in Australia.
- Similarly, the estimates provide only a small subset of the data required to make assessments of what assistance would be needed to avoid undue levels of carbon leakage, and competitive disadvantage. Additional countries and relevant industries would also need to be assessed.

This concluding chapter looks again at the approach taken and relevant caveats, summarises some key results and then draws out some implications for assessing comparative effort and competitiveness effects.

6.1 Recapping on the Commission's approach

If all greenhouse gas emissions were 'priced' directly, comparing prices across countries would be straightforward, but this approach is not common.

- The European Union emission trading scheme (ETS), covering both Germany and the United Kingdom, is one point of reference. But permit prices are influenced by the coverage of the scheme — which is still limited — and the cap on emissions.
- New Zealand has introduced an ETS, and the carbon price has been capped as an interim measure.
- Other countries are contemplating introducing explicit carbon pricing (Japan and South Korea, for example, as well as Australia), but there has been no firm indication of what the carbon prices will be.

When the analysis is broadened to include the impacts of the many non-price emissions-reduction measures, the analytical task becomes much more complicated. The idea that these impacts could be measured in price terms has broad appeal, but there is no clear definition of, or basis in theory for, such a measure (chapter 3).

What all emissions-reduction policies have in common is that they generally impose costs that someone must pay in order to reduce emissions. It is in this sense that the Commission has interpreted 'effective carbon price' loosely to mean the cost of reducing greenhouse gas emissions. This led to the conclusion that the best metric for comparing disparate policies was abatement costs, which in this study has been estimated by comparing the costs and associated emissions of each policy measure (or bundle of measures) with a counterfactual of no policy.

But the abatement cost results cannot be said to be carbon prices. This is because an explicit carbon price applied broadly to the economy would achieve abatement in quite different, and most likely much more cost-effective, ways. Thus for example, a country might be achieving some abatement through subsidising biofuel production, which has been shown to be a high-cost abatement option (chapter 5). Because a broad-based carbon tax would work on both the demand and supply sides of the economy and encourage the lowest cost abatement options to be taken up first, it would not need to be as high as the biofuel subsidy rate to achieve the same level of abatement. Thus, while it is possible to calculate a tax equivalent that will

give the same amount of abatement as the biofuel subsidy (or any other measure that gave the same abatement), application of that tax equivalent would most likely not induce abatement through biofuels.

Measuring abatement costs

Abatement costs should ideally be measured in terms of the impacts on total economic welfare. This requires estimating the costs of inducing substitution on the supply side (the additional *resource costs* of production) as well as the costs of reduced consumption on the demand side where product prices are pushed up (*consumption cost*s).

On the supply side, the Commission estimated the subsidy equivalent for all material policy measures for which data could be obtained. The subsidy equivalent is the explicit or implicit subsidy provided to suppliers of low-emission, but high-cost, products to enable them to be competitive with high-emission but low-cost products. It is indicative of the true (resource) costs, but will generally overstate them (where marginal costs are increasing). However, as long as they do so consistently — and for similar bundles of technologies, such as biomass, wind or solar photovoltaic this is a reasonable presumption — cross-country comparisons can still usefully be made. Subsidy equivalents are also of interest in their own right, because they capture the often hidden transfers to producers.

On the demand side, the Commission estimated consumption costs for those policy measures that directly impact on firms and consumers, such as carbon taxes or fuel taxes. It also estimated consumption costs for supply-side policy measures where the subsidy is effectively paid for by firms and consumers — such as where the cost of purchasing renewable energy certificates is passed on, in whole or in part, by electricity retailers in electricity prices. This necessitated using some simplifying assumptions about demand responsiveness and cost pass-through to provide indicative results in this area.

Abatement was estimated relative to the counterfactual of what emissions would have been in the absence of a given policy. This can depend on the circumstances. In the case of electricity generation, for example, the marginal generator that is replaced when renewable energy generators are dispatched can vary depending on market circumstances, and this can have a substantial impact on the amount of abatement that can be attributed to a policy.

Some limitations

It is important to be clear about the uncertainties inherent in this analysis and the assumptions that needed to be made.

- Unsurprisingly, data proved difficult to obtain for some policy measures and some technologies, particularly in the non-English speaking countries included in the study. The Commission received valuable cooperation from most governments and many research organisations, and it employed contractors to help obtain information, but some uncertainties and gaps remain.
- As noted, the 'counterfactual' scenario can differ depending on the circumstances. Sensitivity analysis was accordingly used to capture the range of possible outcomes.
- The analysis only provides a snapshot for the most recent year for which data were available. As some programs are ramping up over time, it can be expected that, other things being the same, cost and abatement will rise. While the Commission was asked to look at 'committed' policies, in most cases there was insufficient data to estimate the cost impacts of these schemes, other than to offer a qualitative indication.
- Costs and abatement are attributed to some policies that have multiple objectives and there is uncertainty about how much might reasonably be apportioned to each. Sensitivity analysis was again used to test this. Thus, for example, the analysis of fuel taxes considered the extremes of them being solely an emissions-reduction measure or not.
- The study countries provide a useful benchmark in the sense that they include many of the largest emitters, but they are not the home to the competitors of many Australian companies (competiveness issues are taken up below).
- Some policy measures work in the opposite direction by implicitly encouraging emissions. But as these may be achieving other objectives, and/or acting indirectly, it would have been very difficult to factor these in to the analysis.

6.2 Some key results

The Commission estimated the total subsidy equivalent (as a proxy for the resource costs), and the abatement attributable to the subset of policies that are having the greatest impact in each country. Dividing the former by the latter gives the average implicit abatement subsidy, which is the proxy for the unit cost of abatement. The Commission also calculated some indicative estimates of the consumption costs on the demand side.

Electricity supply side

The implicit abatement subsidies — which are also measures of cost effectiveness — varied considerably across policies and also across countries (table 6.1), depending in part on each country's policy mix.

- The lowest implicit abatement subsidy estimate was for New Zealand, for which only one electricity-sector policy was analysed — the recently-introduced ETS.
- Despite their participation in the European Union ETS, estimated implicit abatement subsidies in Germany and the United Kingdom are relatively high. This is because of the generous subsidies that the two countries provide to renewables.
- Policies analysed in Japan and South Korea achieved very low levels of abatement, at a relatively high resource cost (mainly because of high production subsidies paid to high-cost solar photovoltaic), hence the implicit abatement subsidies are high.
- The range of the estimated implicit abatement subsidy for Australia (A$44–99) was lower than for some countries, and at the low end, comparable with China and the United States.

Table 6.1 **International comparison table — electricity generation policies**

Country	*Total subsidy equivalent*	*Total subsidy equivalent as a percentage of GDP*	*Total abatement*	*Abatement as a percentage of counterfactual electricity sector emissions*[a]	*Implicit abatement subsidy*
	A$m (2010)	%	Mt CO_2	%	A$/t CO_2
Australia	473–694	0.04–0.05	7.0–10.7	3.5–5.2	44–99
China	1 835–2 309	0.03–0.04	40.7–52.1	1.2–1.5	35–57
Germany	10 019–11 769	0.28–0.33	67.1–73.1	18.3–19.6	137–175
Japan	669–940	0.01–0.02	3.3–4.3	0.8–1.1	156–287
New Zealand	..	..	..	..	8–10
South Korea	313–379	0.03–0.03	0.9–1.4	0.5–0.7	225–401
United Kingdom	2 042–2 433	0.08–0.10	12.3–27.4	7.5–15.4	75–198
United States	2 886–3 339	0.02–0.02	66.5–66.7	2.8–2.9	43–50

[a] 2010 for China, 2009 for United Kingdom and Germany, 2008 for Japan and Korea. .. Not applicable.

Source: Appendixes D-K

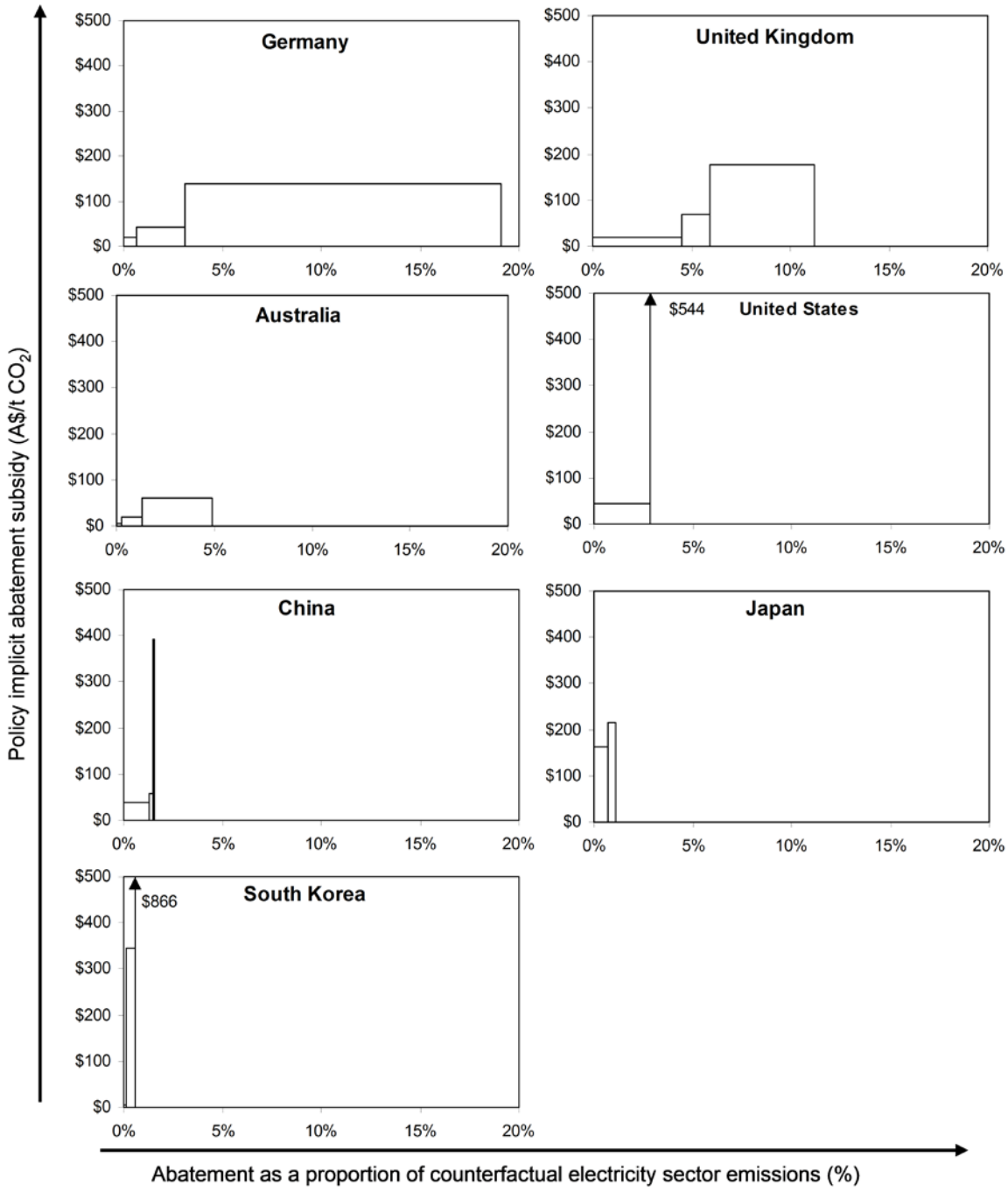
In many cases, overlaps between policy measures makes it impossible to separately report the abatement each achieves. But where they are separable (or at least can be separated into one or more groups of policies), the implicit abatement subsidy

estimates can be used to compare the resource costs of different technologies for reducing emissions (figure 4.4) and the reliance of countries on particular policy measures (figure 6.1). Notable features include:

- Subsidies for solar-photovoltaic systems were found to be a relatively very costly way of achieving abatement and generally little abatement resulted. (These are visible as the very high thin bars in the charts for China, South Korea, the United States and to a lesser extent Japan.) Although a feature of the policy mix in Australia, solar subsidies were deemed to have overlapped with the large and small renewable energy targets, and hence abatement could not be separately identified.
- Germany obtained most of its abatement from relatively high-cost feed-in tariffs (the wide block at A$137/t CO_2).
- The United Kingdom had a mixed outcome, achieving low-cost abatement from fuel switching through the incentives created by the European Union ETS (the low flat bar at A$29/t CO_2) and a similar amount of abatement from its much higher cost Renewables Obligation (at A$176/t CO_2).
- The United States obtained most of its measured abatement from a combination of three policy measures, two federal tax credits and the renewable portfolio standards operated by many states (combined these are estimated to have an implicit abatement subsidy of A$43/t CO_2).
- China's main contributor was its wind feed-in tariff at around A$38/t CO_2.
- Australia's suite of policies (discussed later), was dominated by the combined effects of the large and small−scale components of the renewable energy target and feed-in tariffs (giving an average implicit abatement subsidy of A$62/t CO_2).

Figure 6.1 **Marginal abatement costs — electricity-generation sector[a]**

Graphs show the Commission's 'central' estimates of abatement (as a proportion of counterfactual electricity-sector emissions) and implicit abatement subsidies



a The vertical axis was truncated at A$500/t CO_2. Where the estimated implicit abatement subsidy for a policy was above this level the implicit abatement subsidy estimate is shown on the graph.

Source: Productivity Commission estimates.

Road transport supply side — biofuels

Analysing the key policies for each country indicates that Australia's implicit abatement subsidy for biofuels was similar to the United Kingdom, Germany and New Zealand. However, costs and abatement vary widely across these countries (table 6.2).

- The United Kingdom, Germany and the United States — all with fuel content mandates — had high estimated total subsidy equivalents and abatement.
  - Germany stands out for having the highest abatement when measured against counterfactual emissions for the transport sector (3.6 per cent) at an implicit abatement subsidy of A$310/t CO_2-e, which was at the lower end of the results for all countries.
  - The United States stands out for substantial abatement but at very high cost (the implicit abatement subsidy was estimated to be in the range A$604–A$672/t CO_2-e).
- New Zealand committed a very small amount of resources to biofuels and hence was achieving very little abatement.
- Japan and South Korea had relatively high cost biofuel schemes, with minimal abatement.

The results for China suggest that only under the most favourable assumptions could its biofuel policies have been achieving net abatement. Under most plausible scenarios, the net abatement was negative. This amounts to China having effectively subsidised emissions rather than abatement. This result appears to be due to the high application of fertiliser to grow feedstock for ethanol, and the emissions intensity of refining processes in China.

In summary, while the results for biofuels vary and are particularly sensitive to assumptions about life-cycle emissions intensities, most biofuel policies are high-cost means of achieving abatement. Cost per tonne of abatement — as measured by the implicit abatement subsidy — is typically A$300–A$600/t CO_2-e and possibly as high as A$800/t CO_2-e. This cost is substantially higher than for most supply-side measures in electricity generation (though broadly comparable with solar subsidies).

Table 6.2 **International comparison table — biofuel policies**

Country	*Total subsidy equivalent*	*Total subsidy equivalent as a percentage of GDP*	*Total abatement*	*Abatement as a percentage of counterfactual road transport emissions*	*Implicit abatement subsidy*
	A$m (2010)	%	Mt CO_2-e	%	A$/t CO_2-e
Australia	144	0.011	0.4	0.6	364
China[a]	1 998	0.03	..	..	..
Ethanol	..	..	-1.4 to +0.8	-0.4 to +0.2	-6 105
Biodiesel	..	..	0.2	0.06	592
Germany	1 711	0.05	5.5	3.6	310
Japan	57	0.001	0.1	0.04	617–653
New Zealand	3	0.002	0.01	0.06	391
South Korea	196	0.02	0.2–0.5	0.3–0.6	415–831
United Kingdom	680	0.03	2.0	1.7	335
United States	12 470–17 477	0.08-0.11	19-26	1.2–1.7	604–672

a Results for China are presented separately for ethanol and biodiesel due to the negative abatement result for ethanol. Only a central estimate is given for the implicit abatement subsidy for ethanol; this estimate reflects negative abatement (not cost). **..** Not applicable.

Source: Appendix N.

Road transport demand-side analysis

Of the biofuel policies analysed, the Commission has only explored the demand-side impact of fuel mandates because these are the only type of biofuel policy likely to affect retail prices. Fuel mandates were analysed for the United States, Germany and the United Kingdom. These mandates tend to increase fuel prices because they require petrol and diesel to be blended with more costly biofuels. However, the Commission's results suggest that the mandates appear to have had only a modest effect on prices, with at most an impact of around 1-2 cents per litre on retail prices of petrol and diesel.

By comparison, if regarded as emissions-reduction measures, the various taxes on fuel, such as excise taxes, (but excluding broad based consumption taxes) may be preventing emissions from road transport being much higher than they would otherwise. As for electricity, the Commission had to make some simplifying assumptions about demand responsiveness. In this case, these are even more speculative given the much larger tax-induced changes in price. But even if demand is only mildly responsive to price, it is likely that fuel taxes have led to substantially lower emissions relative to the counterfactual of no fuel taxes. For example, the high estimate for Germany indicated that abatement relative to the counterfactual was approximately 41 per cent. The consumption costs associated with this also appeared to be relatively modest.

But in most countries these taxes have been used for general taxation purposes and/or as quasi 'road-user charges'. Therefore, any abatement could be considered to be incidental. In some cases, such as the United Kingdom, recent adjustments to fuel taxes have been justified in part on emissions reduction grounds, but so far these increments are small relative to the pre-existing tax rates, and some countries have made no such distinction. But if anything these results point to the added effect a carbon tax could have on top of existing fuel taxes.

6.3 Implications for 'effort'?

There is significant interest in understanding the relative effort of different countries in mitigating climate change. 'Effort' implies some sort of sacrifice that a country is making to achieve a given level of abatement. But sacrifice is difficult to define. For example, some see it as meaning that each country should reduce its emissions by the same proportion, others that countries should suffer the same proportionate losses in national income. The different commitments made by parties to the Copenhagen Accord illustrate diverse views, with some countries committing to absolute reductions from a past base year, others advocating reductions against some business-as-usual projection, and yet others advocating decreases in emissions intensity.

The economic impacts will vary according to the approach taken and the characteristics of each economy. Even if all countries had identical carbon taxes, it could not be said that each was making the same *abatement* effort.

Given the problems of defining and measuring effort, this study can only provide some circumstantial evidence of relative effort. There are two ways it does this: through an overview of the breadth and depth of the policy action each country is taking; and scaling costs and abatement achieved by GDP and (counterfactual) emissions, respectively.

Policy actions

Most study countries have adopted a large and diverse range of emissions-reduction policies. For example, the Commission identified more than 300 significant state and federal policies in the United States, and around 120 in the United Kingdom. And Australia itself has around 200 policy measures (chapter 2). These include ETSs in some countries (or regionally), and a range of less direct measures, such as mandatory renewable energy targets, feed-in tariffs, energy efficiency measures and capital subsidies for constructing or installing renewable energy technologies.

Of course, sheer numbers of policies say little in themselves about the materiality or effectiveness of the aggregate response made by governments. Australia and the United States have many policies in place partly because they are federations and their states are active in environmental policy. New Zealand, on the other hand, which has a unitary system of government and a natural endowment of hydro power, has achieved a more focused policy mix centred around explicit carbon pricing.

Some of the breadth in the policy mix can be explained by the use of complementary policies that are intended to address market failures other than the externality associated with greenhouse gas emissions (for example, energy efficiency policies that address information asymmetries). It can also be explained through the rebadging of existing policy instruments. (For example, fuel taxes are increasingly being seen as ways of discouraging fossil-fuel consumption and hence greenhouse gas emissions).

But it is also evident that there is much overlap and inconsistency in the policy mix of most countries. Different levels of government can be supporting the same project, not adding to abatement but adding to cost (for example, the US Federal Government subsidies for renewable energy and state mandatory renewable energy targets). Even at the same level of government, overlaps exist. For example, the United Kingdom and Germany are part of the European Union ETS — which covers electricity generation — yet the United Kingdom has continued to employ a mandatory renewable energy target and Germany has continued to employ very generous feed-in tariffs. Perversely, Germany's high level of support for renewable electricity reduces the emissions-reduction burden that must be borne by the rest of the European Union, lowering ETS permit prices, and leading to increases in emissions in other EU countries at Germany's expense (Traber and Kemfert 2009).

One feature of the policy mix of most countries is that they are in a state of flux. With the European Union ETS now well established and its coverage growing, New Zealand's fledgling ETS, some regional schemes in North America, and other countries such as South Korea, Japan and China intending to trial or adopt such schemes, explicit carbon pricing appears to be coming to the fore. But it is not clear if this will lead on to the rationalisation of other, more costly mechanisms.

Cost and abatement being achieved

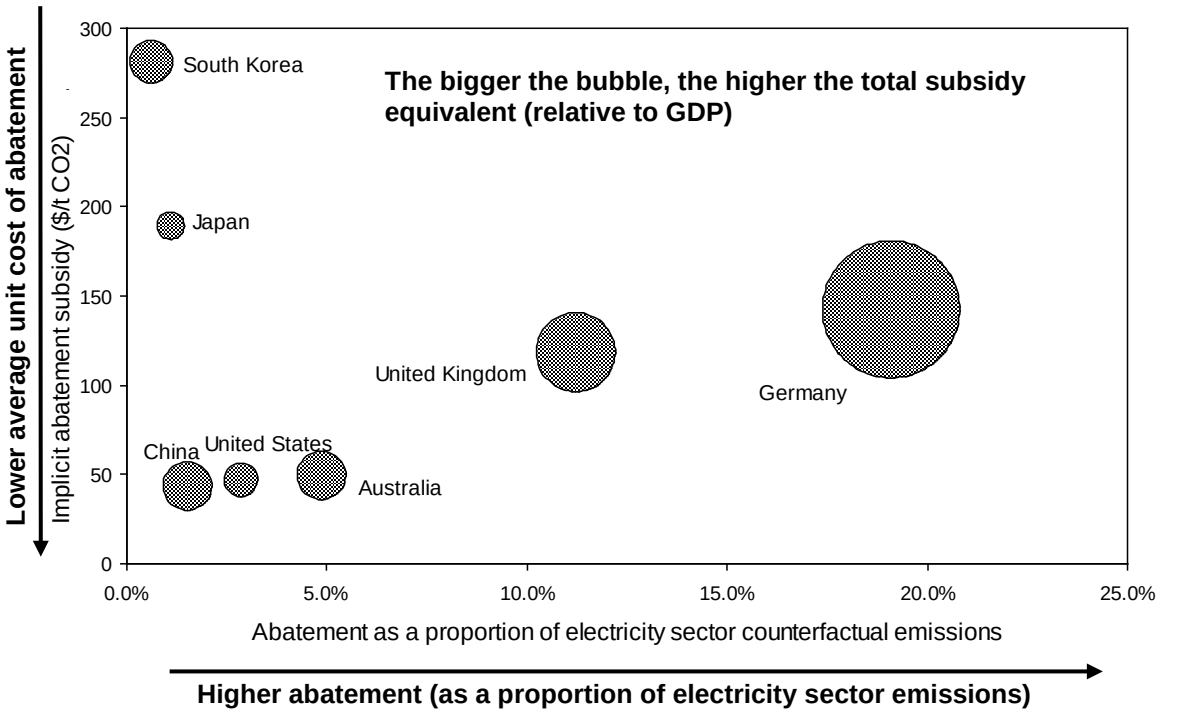
The other way this study can shed some light on effort is by relating the cost incurred by each country in reducing emissions to the size of their economies, and comparing abatement to their sectoral emissions (table 6.1 and 6.2).

Electricity generation

When the total subsidy equivalent of each country's abatement policies was 'scaled' by expressing it as a proportion of GDP, Australia's commitment of resources (measured by the size of its bubble in figure 6.2) was much the same as for South Korea and China. But relative to South Korea, Australia's suite of measures was much more cost effective and produced proportionately more abatement, and relative to China they were about as cost effective, but achieved greater proportionate abatement. Australia achieved more proportionate abatement than the United States at about the same cost effectiveness, but devoted more of its GDP to achieving this outcome.[1] The United Kingdom and Germany are again shown to have devoted substantial resources to achieving abatement. Germany achieved substantially more abatement than the United Kingdom but at a slightly higher average cost. Japan's resource commitment was smaller than most other countries, the unit cost was high, and abatement small.

Figure 6.2 **'Effort' and reward — how countries compare**

Electricity generation — central estimates



Source: Appendixes D to K.

[1] But as noted in Chapter 4, of all study countries, the results for the United States are more likely to be underestimated due to the possible omission of other material policy interventions.

Some care needs to be taken in interpreting the data. Other things being the same, average costs of abatement would be expected to rise as abatement increases. This might be expected if policy makers have targeted assistance at the lowest-cost abatement options first. Indeed, if South Korea and Japan are excluded, the results for all other countries exhibit this trend. However, other things are clearly not the same. There are likely to be some large differences in the costs of the same renewable generation technologies, if for no other reason than that some countries will have different endowments of wind or solar resources (for example), and the different mixes of policies will influence average costs.

Biofuels

Using the same approach for biofuels reveals that, as a proportion of GDP, Australia's commitment of resources to achieving abatement is less than for most other study countries, but that cost effectiveness appears comparable to Germany and the United Kingdom, being roughly in the range of A$300-A$400/t CO_2-e (figure 6.3). But Australia is achieving relatively less abatement when measured as a proportion of transport-sector emissions. Germany is devoting considerable resources to biofuels, but is achieving the highest proportionate amount of abatement. The United States stands out in this analysis for having by far the highest commitment of resources relative to GDP, for only moderate proportionate abatement and hence low cost effectiveness.

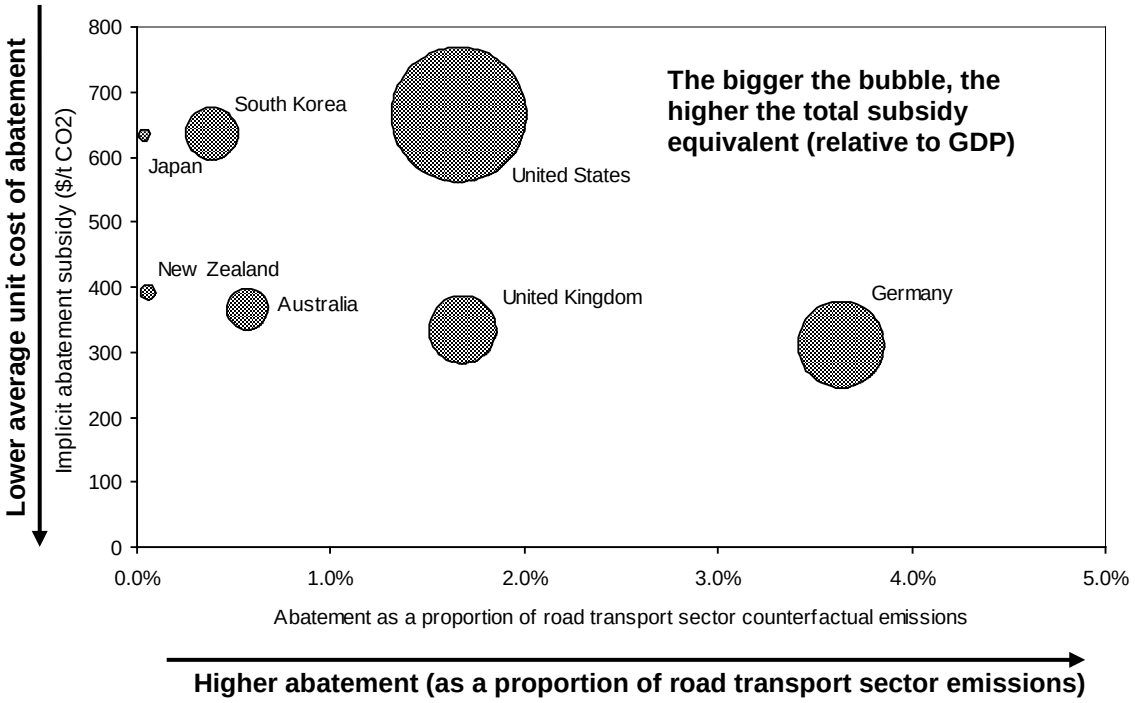
Demand-side abatement and consumption costs

The demand-side abatement results discussed above could also be considered to shed some light on effort, as indicative as they are. The impacts on UK and German consumers of electricity and road-transport fuels stand out in this regard. Both countries have costly policy measures supporting low-emissions generation, which in combination with the European Union ETS, are estimated to have raised retail electricity prices by over 10 per cent. In road transport, the impacts of fuel taxes on abatement and hence consumption costs for most countries are considerable. Germany and the United Kingdom stand out, with fuel taxes of A$0.78 and A$0.96 per litre respectively (table 5.16), with Australia mid-range at A$0.36 per litre.[2] But if these taxes are considered to be primarily for other purposes, such as funding roads or as a revenue-raising measure, it is not valid to attribute high-tax countries with additional effort.

2 These are weighted averages of the rates applying to different road transport fuels.

Figure 6.3 **'Effort' and reward — how countries compare**

Biofuels — central estimates



Source: Appendix N

In summary, such analysis can tell us relatively little about comparative effort per se, other than that some countries have devoted proportionately more of their national resources to achieving abatement than others, though with varying cost effectiveness. The results also illustrate the traps in using simple metrics to indicate effort.

- A relatively high implicit abatement subsidy does not necessarily indicate that a country also experiences a greater proportionate impact on its economy, or emissions, than other countries.
- A country that adopts high-cost abatement opportunities should not be given greater credit than a country that achieves the same abatement at lower cost. Indeed, the more cost effective the abatement policy, the greater the abatement that becomes possible for a given cost.

Least-cost abatement

As noted above, the cost effectiveness of a country's policy measures in aggregate can be put into perspective by estimating the explicit carbon price (from either a

carbon tax or emission permits) that would achieve the same amount of abatement when applied on an economy-wide basis.

This can be illustrated using a (hypothetical) marginal abatement cost (MAC) curve that shows all feasible abatement options in ascending order (including by reducing relatively low-value consumption) (figure 6.4).

- For various reasons, governments have found it difficult to implement the lowest-cost options first, meaning they may support a suite of relatively high-cost options (shown as the 'Policy MAC curve').
- If instead, all abatement options were considered and adopted in order of lowest to highest cost, the same amount of abatement could be achieved at a lower (marginal) cost (P_2 versus P_1).
- Conversely a much greater level of abatement could be achieved at the same (marginal) cost (A^{**} instead of A^{*}). (Note that total cost is measured by the area under the respective MAC curves, and the average cost of abatement will be less than the marginal cost.)

The abatement costs of the three existing policy measures analysed in this study for Australia have been plotted in figure 6.5 to create, in effect, an Australian 'policy MAC curve' for electricity. (The demand-side effect is shown separately and labelled 'electricity consumption costs'). The central estimates of abatement for these policies comes to around 12.5 Mt CO_2.

Stylised modelling using an 'off-the-shelf' version of the MMRF model of the Australian economy suggests that a carbon tax or ETS permit price would have achieved the same abatement at much lower cost. For example, according to the modelling, if applied only to the electricity sector, an explicit carbon price of about A$9/t CO_2 (corresponding to P_2 in figure 6.4) is required.

This equates to about 11 per cent of the almost A$500 million estimated cost of the existing policies. Alternatively, for the same aggregate cost, more than twice the abatement could be achieved. One of the reasons an explicit carbon price would be expected to be more cost effective at such low levels of abatement is that, as modelled, it captures a considerable amount of low-cost abatement on the demand side.

Figure 6.4 **Marginal abatement cost (MAC) curves and cost effectiveness: a hypothetical illustration**

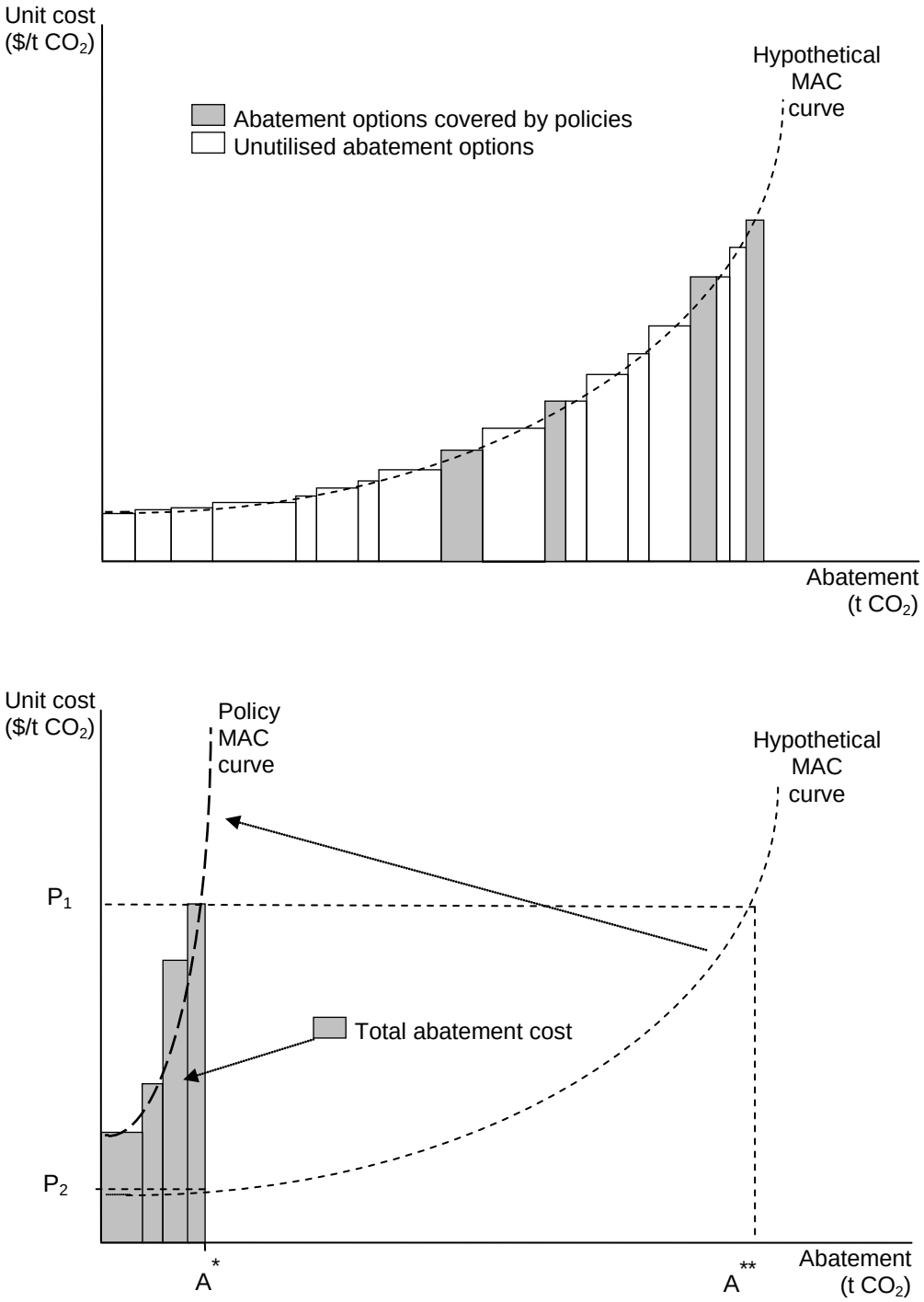
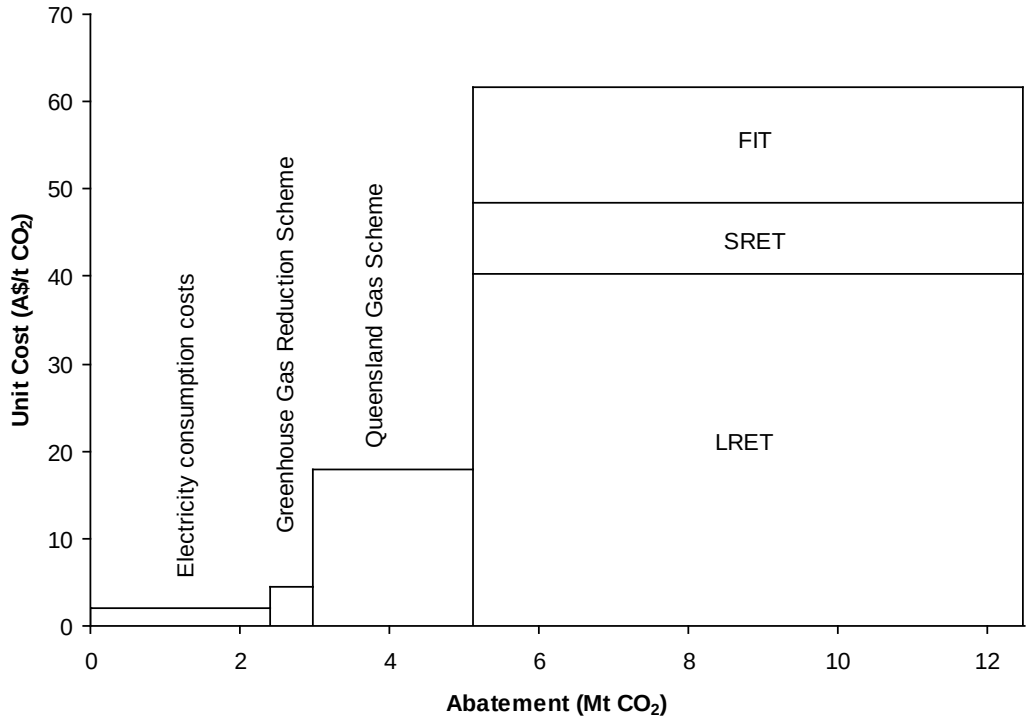


Figure 6.5 **Marginal abatement costs, Australian electricity**
'Central' estimates, 2009-10



Source: Productivity Commission estimates.

This worked example is relatively simplified and cannot be used to infer what the explicit carbon price would need to be to achieve Australia's abatement objectives (something that the Australian Treasury model is better equipped to address). But it illustrates how much more cost effective abatement can be if, in place of other more costly measures, an explicit carbon price is applied to both the demand and supply sides of a broader set of emissions-reduction opportunities within the electricity sector. Extending such a price across the economy would make it even more cost effective. By the same token, a carbon price in combination with other measures will generally be less cost effective than one operating on its own.

6.4 Implications for competitiveness?

When governments intervene to encourage the provision of low-emissions but high-cost production in place of high-emission, low-cost production, they can obviously have an effect on the competitiveness of businesses using that production as an input. The potentially more vulnerable firms will be those that are energy

intensive and trade exposed. In the context of this study, those firms would be the larger users of electricity and/or road transport fuel.

But the actual impact on a firm's costs will depend on how the government chooses to intervene.

- Explicit budget subsidies decrease the costs of the low-emissions producers, enabling them to be competitive at prevailing market prices. While businesses using these products will not have to pay for the subsidies via higher prices, taxes will need to be higher (or government spending lower elsewhere), with ramifications throughout the economy.
- Implicit subsidies to low-emissions producers will generally be passed on via higher prices to consumers and user industries, reflecting higher average costs of production.
- Explicit carbon taxes or trading schemes will directly increase product costs according to their emissions intensity, with these costs being passed on to consumers and user industries.

In this study, the Commission has estimated the impact of a sample of emissions-reduction policies on the retail prices of electricity and transport fuels. With the exception of taxes on road-transport fuels, the estimates are illustrative or at most indicative, for the reasons explained (section 6.1).

But even if these impacts were known with certainty, this information would still be of limited use in assessing impacts on the competitiveness of individual firms. This would require detailed information for particular firms and industries, including knowledge of the cost functions for the comparable industries in the competing countries, relative energy intensities, the net impacts of other policy measures affecting the cost of production, and the ability to pass on costs. Moreover, Australian firms may compete with firms in a wide range of countries — in many cases including countries other than those in this study — and the position would change as market conditions and exchange rates change.

The results for the electricity-generation and road-transport sectors vary considerably and need to be considered separately. In road transport, the Commission looked at support for biofuels as replacements for fossil fuels, and the impact of taxes on fuel prices.

Road-transport fuels are used widely in all economies for private consumption purposes, and as an input to business. Increases in the price of fuels could therefore have wide and diffuse impacts on the economy, with some businesses more affected than others.

- All countries impose substantial taxes on transport fuels, which can increase the cost of doing business. But the degree to which increases in fuel taxes might impair competitiveness will vary according to how much firms can claw back through tax credits or income tax deductions.
- Most biofuel policy measures are budget funded and (pre tax) fuel prices are determined in international markets and hence there are no direct effects. The only policies that do have impacts on retail prices seems to be the fuel mandates operated in Germany, the United Kingdom, and the United States, where they are binding. But even in these cases the impacts on fuel prices seem to be very modest to date (less than A$0.02 per litre).

In the case of electricity generation, the results are a little different, partly because electricity is generally not traded internationally and the industry can pass on cost increases to some extent. As this study has shown, most countries have some very costly policy measures, such as feed-in tariffs for renewable electricity, which are paid for by firms and households. The cost per unit of electricity from these schemes might be high, but to date the overall amount of electricity generated through these measures has, for most countries, been quite small. Hence, there has only been a relatively small impact on product prices to date. For example, the price impacts for Australia appear to have been of the order of 1 to 2 per cent in 2010. But there are exceptions, including Germany and the United Kingdom, where the impacts on retail prices appear to have been of the order of over 10 per cent. This would be an issue for firms in those countries that consume large amounts of electricity (and would work to the advantage of energy-intensive Australian firms competing against those firms).

The finding that average abatement costs are not particularly useful in assessing competiveness means that they are also not particularly useful for setting assistance for emissions-intensive trade-exposed firms. The analytical framework for considering assistance issues under the mixed bag of policies that apply in most countries is perhaps even more challenging than it would be under explicit carbon prices.

In summary, while the overall impacts of the policy measures analysed appears to be relatively small for most countries, the consistent finding from this study is that much lower-cost abatement could be achieved through broad, explicit carbon pricing approaches, irrespective of the policy settings in competitor economies.

A Study participants

As noted in chapter 1, for this study the Commission consulted with the business sector, government agencies and other interested parties, and utilised research expertise in the study countries. The tables below list the relevant parties and the nature of their involvement in the study.

Table A.1 **Meetings with interested parties**

Participant
AGL
Australian Energy Market Operator
Bureau of Infrastructure, Transport and Regional Economics (Australia)
Business Council of Australia
Clinton Foundation
Delegation of the European Union to Australia
Department of Climate Change and Energy Efficiency (Australia)
Department of Infrastructure and Transport (Australia)
Garnaut Climate Change Review
Independent Pricing and Regulatory Tribunal (New South Wales)
National Generators Forum
New Zealand Emissions Trading Scheme Review Secretariat
Refrigerants Australia
Rio Tinto
Treasury (Australia)

Table A.2 **Participants in the methodology roundtable**

Melbourne, 1 December 2010

Participant
Australian Bureau of Agricultural and Resource Economics and Sciences (Australia)
Australian Industry Greenhouse Network
Bureau of Infrastructure, Transport and Regional Economics (Australia)
Centre for International Economics
Centre of Policy Studies (Monash University)
Climate Change Institute (Australian National University)
Commonwealth Scientific and Industrial Research Organisation
Department of Climate Change and Energy Efficiency (Australia)
Department of Resources, Energy and Tourism (Australia)
Energy Supply Association of Australia
Essential Services Commission (Victoria)
Garnaut Climate Change Review
Professor Peter Lloyd (University of Melbourne)
Treasury (Australia)
Vivid Economics

Table A.3 **Productivity Commission presentations to industry groups**

Date	*Industry group*	*Location*
1 March 2011	National Generators Forum	Melbourne
18 March 2011	Business Council of Australia	Sydney
23 March 2011	Australian Industry Greenhouse Network	Canberra

Table A.4 **Government agencies providing data and policy information**

Agency
Bureau of Infrastructure, Transport and Regional Economics (Australia)
Chief Minister's Department (Australian Capital Territory)
Committee on Climate Change (United Kingdom)
Department of the Chief Minister (Northern Territory)
Department of Climate Change and Energy Efficiency (Australia)
Department of Energy (United States)
Department of Energy and Climate Change (United Kingdom)
Department of Environment and Conservation (Western Australia)
Department of Foreign Affairs and Trade (Australia)
Department of Innovation, Industry, Science and Research (Australia)
Department of Premier and Cabinet (New South Wales)
Department of Premier and Cabinet (Victoria)
Department of the Premier and Cabinet (Queensland)
Department of the Premier and Cabinet (South Australia)
Department of Premier and Cabinet (Tasmania)
Department of Resources, Energy and Tourism (Australia)
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany)
Ministry for the Environment (New Zealand)
Ministry of Economy, Trade and Industry (Japan)
Ministry of Environment (Japan)
National Development and Reform Commission (China)
Treasury (Australia)
United States Environmental Protection Agency

Table A.5 **Contractors providing data and policy information**

	Coverage	
Contractor	*Countries*	*Sectors*
Energy Research Institute (National Development and Reform Commission)	China	Electricity generation and road transport
Frontier Economics	Australia, Germany and United Kingdom	Electricity generation
Korean Energy Economics Institute	Korea	Electricity generation and road transport
Resources for the Future	United States	Electricity generation and road transport
Vivid Economics, AEA Technology and Covec (consortium)	Australia, China, India, Japan, Germany, New Zealand, South Korea, United Kingdom and United States	Electricity generation and road transport

Table A.6 **Other organisations providing assistance**

Organisation
Institute of Energy Economics, Japan

Table A.7 **Government agencies invited to provide feedback on data**

Country	*Agencies*
Australia	Chief Minister's Department (Australian Capital Territory) (stocktake only)
	Department of the Chief Minister (Northern Territory) (stocktake only)
	Department of Environment and Conservation (Western Australia) (stocktake only)
	Department of Infrastructure and Transport
	Department of Climate Change and Energy Efficiency
	Department of Innovation, Industry, Science and Research
	Department of Premier and Cabinet (New South Wales) (stocktake only)
	Department of Premier and Cabinet (Victoria) (stocktake only)
	Department of the Premier and Cabinet (Queensland) (stocktake only)
	Department of the Premier and Cabinet (South Australia) (stocktake only)
	Department of Premier and Cabinet (Tasmania) (stocktake only)
	Department of the Prime Minister and Cabinet
	Department of Resources, Energy and Tourism
	Garnaut Climate Change Review
	Treasury
China	National Development and Reform Commission
Germany	Embassy of the Federal Republic of Germany (Canberra)
	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
	German Emissions Trading Authority
India	Ministry of Environment and Forests (stocktake only)
	Ministry of New and Renewable Energy (stocktake only)
	Ministry of Power (stocktake only)
Japan	Ministry of Economy, Trade and Industry
	Ministry of Environment
New Zealand	Ministry for the Environment
South Korea	Ministry of Environment
	Ministry of Knowledge Economy
	Presidential Committee on Green Growth
United Kingdom	Committee on Climate Change
	Department of Energy and Climate Change
United States	United States Department of Energy
	United States Environmental Protection Agency

B Policies selected for analysis

This appendix provides brief descriptions of the emissions-reduction polices that have been quantitatively analysed in chapters 4 and 5. Policies are presented for the electricity generation and road transport sectors in each study country (excluding India, which chose not to participate in the study). Descriptions of all policies identified by the Commission are provided in the country stocktakes, which are available on the Commission's website.

Table B.1 **Electricity generation, Australia**

Policy type	*Jurisdiction*	*Policy name*	*Description*
Renewable energy certificate scheme	National	Large-scale Renewable Energy Target	Wholesale purchasers of electricity (retailers and large users) are required to purchase large-scale renewable energy certificates (RECs) to achieve annual targets for the overall amount of renewable energy generation. Annual targets increase over time from an initial level of 10 400 GWh of large-scale renewable energy in 2011. Between 2020 and 2030 the annual target is 41 000 GWh.
Renewable energy certificate scheme	National	Small-scale Renewable Energy Scheme	Electricity retailers are required to purchase a certain number of RECs from owners of eligible small-scale renewable energy installations (such as micro-generation, heat pumps and solar water heaters). The scheme does not have an overall general target and the small-scale technology percentage required to be purchased is set each year.
Solar feed-in tariffs	New South Wales	Solar Bonus Scheme	Owners of solar photovoltaic (PV) systems (up to 10 kW) are paid A$0.60/kWh or A$0.20/kWh for all electricity generated (depending on when the system was installed).
Solar feed-in tariffs	Victoria	Premium Feed-in Tariffs	Owners of solar PV systems (up to 5 kW) are paid up to A$0.60/kWh for excess electricity exported to the grid.
Solar feed-in tariffs	Queensland	Queensland Government Solar Bonus Scheme	Owners of solar PV systems (up to 10 kW) are paid A$0.44/kWh for excess electricity exported to the grid.
Solar feed-in tariffs	South Australia	Solar Feed-in Tariffs	Owners of solar PV systems (up to 10 kW) are paid A$0.44/kWh for excess electricity exported to the grid.
Solar feed-in tariffs	Western Australia	Feed-in Tariff	Owners of solar PV systems (up to 10 kW) are paid A$0.40/kWh for excess electricity exported to the grid.
Solar feed-in tariffs	Australian Capital Territory	Feed-in Tariff Scheme	Owners of solar PV systems (up to 30 kW) are paid A$0.40–A$0.50/kWh (depending on the time of year the system was installed) for all electricity generated.

(Continued next page)

Table B.1 (continued)

Policy type	*Jurisdiction*	*Policy name*	*Description*
Emissions trading scheme – baseline and credit	New South Wales	Greenhouse Gas Reduction Scheme	Electricity retailers must meet mandatory emissions-reductions targets that are based on their market share, and must develop and encourage activities that offset emissions. Scheme participants must purchase NSW Greenhouse Abatement Certificates to meet their benchmark — each certificate represents a one tonne reduction in CO_2 emissions.
Electricity supply or pricing regulation	Queensland	Queensland Gas Scheme	Electricity retailers must source a minimum percentage of their electricity from eligible gas-fired electricity. Requirements must be met by surrendering Gas Electricity Certificates that are created for each MWh of electricity produced by eligible gas generators. The mandatory target was 15 per cent of generation in 2010 and will rise to 18 per cent by 2020.

Table B.2 **Road transport, Australia**

Policy type	*Jurisdiction*	*Policy name*	*Description*
Production subsidy	National	Ethanol Production Grants	A subsidy of A$0.38/L (2009-10) is provided to eligible ethanol producers to offset the amount of fuel excise. This subsidy is to be gradually phased out from December 2011 with the introduction of taxes based on the energy content of biofuels.
Production subsidy	National	Cleaner Fuels Grants Scheme	The Cleaner Fuels Grants Scheme provides a payment of A$0.38/L (2009-10) to producers and importers of biodiesel and renewable diesel to offset the amount of fuel excise paid. This scheme is to be abolished in December 2011 with the introduction of taxes based on the energy content of biofuels.
Fuel tax	National	Fuel excise	Australia levies excise on petrol, diesel and most biofuels at the rate of A$0.38/L (with rebates for off-road use), but does not currently tax liquefied petroleum gas (LPG) or other gaseous transport fuels (changes to these arrangements are scheduled to take effect from December 2011).

Table B.3 **Electricity generation, China**

Policy type	*Jurisdiction*	*Policy name*	*Description*
Feed-in tariff	National	Feed-in Tariff for Wind Turbines	Feed-in tariffs for wind generation that vary according to the 'zone' that generators are located in. Rates vary from CNY 0.51/kWh to CNY 0.61/kWh.
Feed-in tariff	National	Feed-in tariff for Biomass	Feed-in tariff of CNY 0.75/kWh for electricity generated from biomass.
Feed-in tariff	Local	Jiangsu Feed-in Tariff for solar PV	Feed-in tariffs for solar PV farms (CNY 1.4/kWh), solar PV rooftop projects (CNY 2.4/kWh) and building-integrated solar PV systems (CNY 2.9/kWh) (rates are for 2011). The target for the scheme is for 400 MW of installed solar PV capacity by the end of 2011.
Capital subsidy	National	The Golden Sun Demonstration Scheme	Subsidies for selected grid-connected solar PV projects (50 per cent of the capital investment) and off-grid solar PV projects (70 per cent of the capital investment).
Capital subsidy	National	Subsidy for Solar PV in Buildings	Capital subsidy of CNY 20/W for solar PV systems of 50 kW capacity or greater that are installed in buildings.
Generator upgrades	National	Large Substitute for Small program	Replacement of small less-efficient coal-fired generators with larger, more efficient generators.

Table B.4 **Road transport, China**

Policy type	*Jurisdiction*	*Policy name*	*Description*
Tax concession	National	Fuel Excise Exemption	Biodiesel and ethanol are exempt from fuel excise and a rebate is paid to producers for the value added tax (levied at 17 per cent). These exemptions only apply to authorised ethanol producers and to biodiesel producers that use at least 70 per cent recycled vegetable oil or tallow.
Production subsidy	National	Flexible Subsidies for Loss	Subsidies are provided to authorised ethanol producers to compensate for losses made in producing ethanol for road transport. The subsidy is based on an evaluation of each individual ethanol producer's annual financial performance.
Fuel content standard	Sub-national	National Scheme of Extensive Pilot Projects on Bioethanol Gasoline for Automobiles	Petrol is required to contain 10 per cent ethanol in six provinces (Heilongjiang, Jilin, Liaoing, Henan, Guangxi and Anhui), nine cities in Hubei province, seven cities in Shandong province, six cities in Hebei and five cities in Jiangsu. Only authorised ethanol producers are able to supply ethanol under this program.
Fuel tax	National	Fuel excise	China taxes petrol and diesel at the national level through the 'Consumption Tax' at rates of CNY 1/L of petrol and CNY 0.8/L of diesel. There is no tax on LPG used as a transport fuel.

Table B.5 **Electricity generation, Germany**

Policy type	*Jurisdiction*	*Policy name*	*Description*
Emissions trading scheme	European Union member states (including Germany)	European Union Emissions Trading Scheme	Electricity generators (and firms in some other sectors) are required to surrender one European Union Allowance (EUA) for each tonne of carbon dioxide they emit. EUAs are internationally traded permits. In the second phase of the European Union ETS (2005–2008), the majority of permits were allocated to firms with ETS obligations. However, during this period around 9 per cent of Germany's allocation of EUAs were auctioned by the German Government. This is scheduled to increase to 70 per cent by the end of the third phase (2010–2020). The scheme does not currently cover road transport fuels but will cover aviation fuels from 2012, with around 85 per cent of permits to be allocated to firms in that year.
Feed-in tariff	National	Renewable Energy Sources Act	Operators of electricity grids are required to purchase and transmit all electricity that is generated from renewable energy sources and mine gas.
Feed-in tariff	National	Combined Heat and Power Act	Payments to combined heat and power generators that vary depending on the age of the plant, its size and its efficiency.

Table B.6 **Road transport, Germany**

Policy type	*Jurisdiction*	*Policy name*	*Description*
Tax concession	National	Fuel Tax Exemption for Pure and Blended Biofuels	Biodiesel and vegetable oil are partially exempt from fuel taxes, with the exemption equivalent to €0.2734/L and €0.3049/L in 2009. The ethanol component of petrol blends (that contain at least 70 per cent ethanol) and 'cellulosic ethanol' are fully exempt.
Fuel content standard	National	Biofuel Quota Act	A minimum amount of biofuel must be consumed as transport fuel each year, either neat or blended with petrol or diesel. Each year, the proportion of biofuel in conventional fuel (petrol or diesel) is set (in terms of energy content). In 2009 quotas were 4.4 per cent for biodiesel (blended with diesel), 2.8 per cent for ethanol (blended with petrol) and 5.25 per cent for all biofuels.
Fuel tax	National	Fuel excise	Germany levies fuel excise on most transport fuels, with a tax of €0.65/L of petrol and €0.47/L of diesel (tax rates are higher for fuels with sulphur content over 10 miligrams per kilogram).

Table B.7 **Electricity generation, Japan**

Policy type	*Jurisdiction*	*Policy name*	*Description*
Renewable energy certificate scheme	National	Renewable Portfolio Standard	Electricity retailers must generate or purchase a certain amount of renewable energy each year (compliance can also be achieved by surrendering RECs). The scheme covers solar PV, wind, biomass, geothermal and hydroelectricity generators (excluding hydroelectricity generators over 1 MW). RECs can be banked and borrowed across years, with some restrictions.
Feed-in tariff	National	The New Buyback Program for Solar Photovoltaic	Electricity utilities are required to purchase excess electricity from solar PV systems exported to the grid. A fixed tariff is provided for 10 years (at rates of ¥20–45/kWh for systems installed in fiscal year 2009 (¥32–42/kWh in fiscal year 2011).
Capital subsidy	National	National PV capital subsidies	Capital subsidies for the installation of solar PV systems in residential buildings. In fiscal year 2009, the subsidy was ¥70 000/kW of solar PV installed (reduced to ¥48 000/kW in 2011).
Capital subsidy	Tokyo	Tokyo PV capital subsidies	Capital subsidies for the installation of solar PV systems in residential buildings, paid at the rate of ¥100 000/kW. This subsidy is provided in addition to the national subsidies listed above.
Fossil fuel tax	National	Petroleum and Coal Tax	Tax on imported fossil fuels, including coal, petroleum and natural gas. Both refined and unrefined imports are taxed. Current tax rates are ¥700/t of coal, ¥1080/t of natural gas and ¥2010/kL of petroleum. These rates will be increased between 2013 and 2015 as part of the 'Special Provision on Taxation for Global Warming Countermeasure', with the rate of increase based on the CO_2 emissions content of each fuel.

Table B.8 **Road transport, Japan**

Policy type	*Jurisdiction*	*Policy name*	*Description*
Tax concession	National	Biofuel excise concessions	Ethanol that is blended with petrol is exempt from fuel excise.
Fuel tax	National	Fuel excise	Japan levies two taxes on petrol (the Gasoline Tax and Local Gasoline Tax), at rates of ¥48.6/L and ¥5.2/L respectively. In addition, there is a Diesel Handling Tax of ¥32.1/L and a tax on LPG of ¥17.5/kg.

Table B.9 **Electricity generation and road transport, New Zealand**

Policy type	*Jurisdiction*	*Policy name*	*Description*
Emissions trading scheme	National	New Zealand Emissions Trading Scheme	The New Zealand ETS covers electricity generation, transport fuels and some other sectors (including forestry and industrial processes). In the transition phase (July 2010 to December 2012), one ETS permit (New Zealand Unit) can be surrendered by firms to cover liabilities for two tonnes of CO_2-e emissions, and firms have the option of paying NZ$25 to the Government instead of surrendering a permit. In addition, some international offsets (such as Certified Emissions Reductions certificates) can be used to meet liabilities. From 2013 one permit will be required per tonne of emissions.
Tax concession	National	Ethanol fuel tax exemption	Domestic producers and importers of ethanol are exempt from the Accident Compensation Corporation Levy on fuel.
Production subsidy	National	Biodiesel Grants Scheme	A subsidy of NZ$0.425/L (2009) for domestic producers of biodiesel with sales of 10 kL per month or more.
Fuel tax	National	Fuel excise	New Zealand levies several taxes on petrol — including excise, the Accident Compensation Corporation Levy, the Petroleum Engine Fuels Monitoring Levy and the Local Authority Petroleum Tax — at a total rate of NZ$0.59/L. Excise is levied on LPG at a rate of NZ$0.10/L. There is a small tax on diesel fuel (less than NZ$0.01/L) since diesel use is taxed primarily through a system of ‘road user charges’ that are based on distance travelled.

Table B.10 **Electricity generation, South Korea**

Policy type	*Jurisdiction*	*Policy name*	*Description*
Feed-in tariffs	National	Feed-in Tariffs	Feed-in tariffs are provided to wide range of new and renewable electricity sources, including wind, solar, biomass, hydro, tidal and fuel cells. The South Korean Government is planning to replace this scheme with a REC scheme in 2012.
Emissions trading scheme	National	Korea Certified Emissions Reductions	A voluntary market for emissions-reduction certificates has been in operation since 2005 for firms that reduce emissions by 500 t CO_2 annually. In practice, the government purchases most certificates at around A$4.75/t CO_2.
Capital subsidy	National	General Deployment Subsidy	Capital subsidies are provided for up to 50 per cent of the cost of installing certain renewable energy systems.
Capital subsidy	National	Regional Deployment Subsidy	Subsidies are provided for building electricity generation infrastructure (100 per cent of costs) and the installation of renewable energy systems (up to 60 per cent of the cost) in some regions.
Capital subsidy	National	1 million Green Homes	Subsidies are provided to small-scale renewable generators (including solar PV, solar thermal, wind, geothermal and biomass) with the aim of having 1 million households using renewable energy by 2020.
Preferential loan	National	Loans Incentive Program	Low-interest government loans are provided for up to 90 per cent of the cost of installing or operating renewable energy systems (with the amount reduced to 50 per cent of costs for large corporations).

Table B.11 **Road transport, South Korea**

Policy type	*Jurisdiction*	*Policy name*	*Description*
Tax rebate or credit	National	Tax rebates for biodiesel	Domestic producers and importers of biodiesel are entitled to a fuel tax rebate of KRW 528.75/L (in 2010).
Fuel tax	National	Fuel excise	Several taxes are levied on petrol and diesel: The Transportation, Energy, Environment Tax; the Education Tax; and the Motor Fuel Tax. The total tax rates are KRW 745.89/L of petrol and KRW 518.18/L of diesel. Other taxes apply to LPG which total KRW 221.06/L.

Table B.12 **Electricity generation, United Kingdom**

Policy type	*Jurisdiction*	*Policy name*	*Description*
Emissions trading scheme	European Union member states (including the United Kingdom)	European Union Emissions Trading Scheme	See table B.5 (Germany).
Fuel or resource tax	National	Climate Change Levy	The non-domestic use of fossil fuels and electricity is taxed (excluding oil, heat, steam and gaseous transport fuels). In 2010 the rate was £0.00470/kWh for electricity with fossil fuels taxed at varying rates. Renewable electricity (with the exception of large-scale hydro) and 'good quality' combined heat and power systems are exempt from the tax.
Renewable energy mandate	National	Renewables Obligation	Electricity retailers are required to purchase Renewable Obligation Certificates created by renewable generators, or alternatively pay a 'fine'. Renewable generators receive different numbers of certificates per MWh depending on the technology used.
Capital subsidy	England	Offshore Wind Capital Grants Scheme	Capital subsidies for the construction of offshore wind farms, set at 40 per cent of costs in excess of the cost of building a conventional power station.

Table B.13 **Road transport, United Kingdom**

Policy type	*Jurisdiction*	*Policy name*	*Description*
Fuel content standard	National	Renewable Transport Fuels Obligation	The Renewable Transport Fuels Obligation requires domestic refineries and importers of refined conventional fuels to ensure that a specified percentage of road transport fuels that they supply are biofuel. The target for fiscal year 2009 was 3.25 per cent by volume of fuel. This has been raised to 3.5 per cent in fiscal year 2010. The scheme includes tradeable certificates and suppliers could 'buy out' of their obligation for £0.15/L in 2009.
Fuel tax	National	Fuel excise	Excise is applied to all road transport fuels in the United Kingdom. In 2010 the rates averaged £0.57/L of petrol or diesel and £0.17/L of LPG. The United Kingdom has justified increases in rates of fuel excise as an emissions-reduction measure.

Table B.14 **Electricity generation, United States**

Policy type	*Jurisdiction*	*Policy name*	*Description*
Tax concession	Federal	Renewable Electricity Production Tax Credit	An annual tax credit for renewable energy production from qualified facilities for the first 10 years of their operation. The rate in 2010 for wind, closed-loop biomass, solar and geothermal was US$0.022/kWh. Other renewable energy sources received US$0.011/kWh. Firms can choose to accept this tax credit or, alternatively, can choose either the Business Energy Investment Tax Credit or an equivalent Section 1603 Treasury Grant.
Capital subsidy	Federal	Section 1603 Renewable Energy Grants (Treasury Grant)	Cash grants to eligible renewable energy investments (facility construction) that are brought into service from 2009. The grant is 30 per cent of costs for fuel cells, solar, small wind, biomass, landfill, geothermal (other than heat pumps) waste and marine, and 10 per cent for geothermal heat pumps, micro-turbines and combined heat and power. Firms can choose whether to receive this grant or, alternatively, can receive either the Business Energy Investment Tax Credit or the Renewable Electricity Production Tax Credit.
Renewable energy certificate scheme	31 states and the District of Columbia	Renewable portfolio standards	Mandatory renewable energy targets (most of which have renewable energy certificates) exist in 36 states and the District of Columbia, with voluntary schemes in an additional five states. The design of these schemes, and the renewable technologies supported, differ across states. All schemes cover wind, solar PV, hydroelectricity, biomass, biofuels and landfill gas. Obligations are placed on generators in some states, and on retailers in others. ‘Alternative compliance payments’ exist in some states, a penalty paid per unit of non-compliance (in effect a price cap).
Capital subsidy	California	California Solar Initiative	Subsidies for solar energy systems. These consist of upfront cash payments (the Expected Performance Based Buydown and the Single-family Affordable Solar Homes scheme) and performance based incentives (feed-in tariffs for the first five years of operation of solar PV systems).
Capital subsidy	California	New Solar Homes Partnership	Subsidies to builders of new residential properties for the installation of solar energy systems. Subsidies vary by the housing type and the expected performance of the system. The base subsidy is US$2.50/W, with higher rates for builders of multiple houses that install solar panels and those that install solar panels on ‘affordable housing’ projects.
Capital subsidy	California	Self-Generation Incentive Program	Payments for distributed energy systems including wind turbines, fuel cells and 'advanced energy storage' systems. Payments are US$1.50/W for wind, US$2.50/W for fuel cells using non-renewable fuels, US$4.50/W for fuel cells using renewable fuel, and US$2/W for advanced energy storage systems.
Capital subsidy	California	Emerging Renewables Program	Payments for the installation of grid-connected small wind and fuel cell renewable energy electricity generation systems (up to 50 kW). The rate paid is up to US$3/W, depending on the type and size of the system (with higher rates for ‘affordable housing’ projects).

Table B.15 **Road transport, United States**

Policy type	*Jurisdiction*	*Policy name*	*Description*
Tax concession	Federal	Alcohol Fuel Credit	Producers of ethanol that is used as a road transport fuel receive a tax credit of US$0.45/gallon (US$0.12/L) of ethanol produced (including the ethanol component of petrol-ethanol blends). Additional tax credits are provided to producers of 'cellulosic ethanol', such that the total rate is US$1.01/gallon (US$0.27/L). Eligible small producers can receive an additional US$0.10/gallon (US$0.03/L) over the first 15 million gallons of biofuel produced each year.
Tax concession	Federal	Biodiesel Fuel Credit	Producers of biodiesel (and renewable diesel) that is used as a road transport fuel receive a tax credit of US$1/gallon (US$0.26/L) of biodiesel produced (including the biodiesel component of diesel-biodiesel blends). Eligible small producers can receive an additional US$0.10/gallon (US$0.03/L) over the first 15 million gallons of biofuel produced each year.
Production subsidy	Federal	Bioenergy Program for Advanced Biofuels	Eligible 'advanced biofuel' producers receive payments for the production of fuel from biomass (excluding maize starch). Payment rates differ depending on the feedstocks used, the size of the facility and the total amount of funding available.. There are also different payment rates for 'base' production (equal to total production over the previous year) and 'incremental' production (additional production within the year).
Tax concession	10 states and the District of Columbia	Excise Concessions for Ethanol	Ethanol is taxed at a lower rate than petrol in some states. These tax concessions are often applied to the two ethanol-petrol blends that can be legally sold in the United States — E10 (petrol blended with 10 per cent ethanol, also called 'gasohol' in the United States) and E85 (petrol blended with 85 per cent ethanol).
Government procurement	Federal	Federal Fleet Management Guidance	Federal government agencies with 20 or more vehicles must reduce their annual consumption of petroleum-derived products by 2 per cent, relative to a 2005 baseline. In addition, agencies must increase their consumption of 'alternative fuels' (including biofuels) by 10 per cent each year until 2015 (relative to 2005).
Fuel content standard	Federal	Federal Renewable Fuel Standard	A minimum volume of biofuels that must be sold each year. In 2009 the requirement was for the consumption of 11.1 billion gallons (42 billion litres) of biofuel, of which 0.5 billion gallons (1.9 billion litres) was expected to be biodiesel (or 10.20 per cent of all petrol sold was required to contain biofuel in that year). Since 2010, both petrol and diesel must contain biofuel and mandates have been set for 'celluosic' ethanol and other 'advanced' biofuels (that is, not maize starch). Most biofuel must also meet emissions-reduction criteria to be used for scheme compliance. Fuel suppliers can meet the requirements of the scheme through the creation of Renewable Identification Number certificates, which are tradable.
Fuel tax	National	Fuel excise	Fuel taxes are levied at the national and state levels in the United States, with significant differences in tax rates and tax systems across states. Federal-level excise rates are US$0.18/gallon (US$0.05/L) of petrol and US$0.24/gallon (US$0.06/L) of diesel. State taxes averaged around US$0.21/gallon (US$0.06/L) of petrol and diesel, and US$0.12/gallon (US$0.03/L) of LPG in 2009.

C Energy efficiency policies

Energy efficiency policies are directed at reducing the amount of energy required to produce a unit of output or to achieve a particular outcome. Depending on the source(s) of energy, to the extent that greater energy efficiency decreases energy consumption, there may also be a reduction in greenhouse gas emissions per unit of output.

C.1 Introduction

Mandating or encouraging improvements in energy efficiency are increasingly seen as important components of the policy framework for reducing greenhouse gas emissions in many developed and some developing countries. Indeed a similar suite of policies are observed across many countries. A key rationale is that unrealised profitable energy efficiency gains are seen as pervasive and offering a low (or even negative) cost means of emission reduction.

For example, the International Energy Association (IEA 2009b) has postulated that most of the greenhouse gas emission reductions needed to limit the global increase in energy-related emissions by 2020 to 6 per cent over 2007 levels, could be attained through improved energy efficiency.[1]

Non-price energy efficiency policies are also often easier to implement politically than tax or price-based policies. Unlike pricing or taxation instruments, the costs of energy efficiency regulations are often not apparent to those paying them.

In a number of key policy areas, most study countries have introduced substantial regulation in both the electricity and transport sectors, although the precise policy tools and stringency differ. In addition, most countries have adopted a diverse range of smaller energy efficiency initiatives, as well as broader emissions-reduction

[1] This would be achieved largely by additional government regulation and a cap and trade emissions trading scheme for the power and industry sectors of OECD and EU countries, starting in 2013 and reaching a carbon price of US$50/t$CO_2$ (A$48) by 2020.

policies that will also have some consequential effect on energy efficiency.[2] The range of policies tends to be greater in countries with sub-national governments.

C.2 Establishing the costs and emissions reductions from energy efficiency policies

To estimate the cost of abatement for the emissions reductions achieved through the numerous energy efficiency policies implemented by many governments, it would be necessary to determine both the abatement attributable to each of these policies and the various costs involved in achieving it. However, there are significant difficulties in making meaningful estimates of both.

Estimating abatement

For a number of reasons, it is often very difficult to estimate abatement attributable to the diverse range of regulatory and information policies that have been used to encourage greater energy efficiency.

Establishing the counterfactual

In an era of generally rising energy prices, significant technological and structural change and increasing community focus on greenhouse gas emissions, ongoing improvements in energy efficiency are likely to be observed. Particularly as new or replacement high value assets are purchased, consumers and firms will place increased emphasis on energy efficiency. If energy prices rise sufficiently, some asset replacement will be brought forward to take advantage of more energy efficient technology. Product technology also evolves to satisfy these demands. In addition, some consumers simply exhibit preferences for improved environmental outcomes and will seek energy efficient products. Some businesses also appear to be becoming more aware of their 'carbon footprint' and the corporate reputational issues attached to it and are making decisions, including investments in increasing energy efficiency, to reduce that impact.

Hence, it is often difficult to identify what improvements in energy efficiency (and the associated costs) are attributable to a particular policy over and above those that would have occurred in the absence of the policy. This is further accentuated when

[2] A more complete listing of energy efficiency based emission abatement policies implemented in the countries under review is included in the individual country policy stocktakes published on the Commission's website.

the impact of regulatory standards on energy use is uncertain, which can be particularly important for heterogeneous assets like residential and commercial buildings and industrial machinery.

If regulated standards wholly or partly reflect what the market would have delivered anyhow, then the potential costs of overriding consumers' preferences are commensurately reduced, but the regulatory transactions costs would then be spread over a smaller amount of emissions reductions.

'Rebound effects'

By lowering operating costs of energy-using equipment — effectively making marginal energy use cheaper — improved energy efficiency can cause a secondary increase in the demand for energy. For example, more fuel efficient motor vehicles make travelling cheaper and hence provide users with an incentive to drive further and more often. This is called the energy efficiency *direct* 'rebound effect'. While the existence of rebound effects is well established, their size can be contentious.

Apart from possible direct effects, privately cost-effective energy efficiency improvements will be wealth enhancing and will stimulate growth, particularly in the sector concerned. Significantly greater indirect energy rebound effects may occur as a result. This can contribute to a potentially large *total* rebound effect.

The Breakthrough Institute (Jenkins, Nordhaus and Shellenberger 2011), in a review of the rebound effect literature, noted that in developed countries, studies had typically identified direct rebound effects in the order of 10 to 30 per cent. It argued that this was likely to be a good deal higher in emerging economies, where demand for energy services was more elastic, with much greater scope to increase demand than in developed countries. Allowing for growth-induced indirect effects significantly increased the rebound effect for cost-effective energy efficiency initiatives, often to over 50 per cent, with several studies predicting a rebound of over 100 per cent — so called 'backfire'.[3] Conversely, indirect rebound effects from policies that are not privately cost effective would be negative, as such policies would be wealth diminishing.

In sum, the potential for rebound effects makes it difficult to determine the extent of energy savings attributable to policy measures promoting energy efficiency. Energy efficiency improvements that arise in response to higher energy prices do not face

[3] While such productivity enhancements are to be welcomed, they do call into question the emission-reduction benefits of such policies. Indeed, from a purely emissions reduction point of view, energy efficiency regulation that is not privately cost effective will tend to generate greater emissions savings, as it will decrease wealth.

these difficulties, however, because they involve an unequivocal increase in net energy costs.

Extent of abatement

For a given reduction in energy demand, the impact on greenhouse gas emissions will depend on the energy source from which the reduction is obtained. For example, if improving air conditioner energy efficiency is mandated, any electricity reduction (net of rebound effects) is likely to occur in periods of peak demand, in which case the electricity displaced may be provided by gas generation. Conversely, falls in energy demand due to more efficient home lighting will involve mostly base-load electricity, suggesting that demand for coal-fired capacity might be reduced. In some cases, however, hydro electricity may be displaced, resulting in no emissions reductions.

In an electricity industry with a mix of fossil fuel technologies and several non-emitting energy sources, it will not always be clear what power source bears the brunt of reductions in energy demand resulting from energy efficiency policies. Electricity suppliers will reduce output from the highest cost source at the time. Because energy efficiency measures do not place a price on greenhouse gas emissions, they do not necessarily influence that decision in favour of reducing fossil fuel-based generation. In a country like New Zealand, where over 70 per cent of electricity already comes from renewable sources, emissions reductions are likely to be relatively small and unit abatement costs commensurately higher.

Estimating the cost of abatement

Determining the net costs (or benefits) of energy efficiency policies is particularly problematic. The costs associated with these programs are often diffuse and difficult to identify or quantify. The size of the costs depends significantly on whether the nature and extent of the intervention is commensurate with the market failures present in the market for energy efficiency (box C.1), and on whether all costs have been considered.

The market failures are mostly information related, and intervention that addressed these directly and in a cost effective way could lead to net private and social benefits. If this was the case, the net costs would be negative and the intervention a true ‘no regrets’ measure. But there can be some important costs that are sometimes overlooked. These are of two broad types: transactions costs and the costs of overriding consumer preferences.

Box C.1 Potential market failures in the demand for energy efficiency

It has often been observed that apparently privately cost effective energy efficiency savings are not taken up by consumers, firms and governments. The Commission (PC 2005) identified a number of barriers and impediments that might explain this. However, only if these represented market failures might policy intervention be justified.

Information deficiencies

If consumers and producers do not have easy access to adequate information on energy efficiency performance, they may 'under invest' in energy efficiency. Of particular importance is information asymmetry, where sellers may have more information than buyers regarding energy efficiency and do not share that information. However, limited knowledge is not of itself a market failure — information is expensive to provide and to obtain and hence it will generally be efficient to have less than perfect information.

Split incentives

Differing incentives can arise when the purchaser of an energy-using product (for example, a property developer or landlord) is different from the eventual user (for example, a home buyer or tenant). This is a form of the principal–agent problem. Due to uncertainty about the returns they may receive, developers and landlords can have less incentive to provide appliances and buildings that are as energy efficient as buyers or tenants actually desire. Such problems can be magnified by information asymmetries, where builders or property owners have more knowledge about the energy efficiency of a building than buyers or renters, and are not willing to fully share that information. In principle, these issues could be dealt with in contract negotiations, but in many cases this may be too complex and expensive given the potential savings.

Positive externalities (spillovers)

These occur where a firm's actions provide benefits to others that it cannot capture. Positive externalities relevant to energy efficiency relate to research and development and demonstration effects of firms being the first to adopt energy efficient technologies.

Negative environmental externalities

The negative externalities associated with CO_2 emissions have provided significantly added incentive for energy efficiency policy. In general, firms and individuals will not take account of these impacts and will have inefficiently high consumption of emissions producing energy. Among other things, this will mean an underinvestment in energy efficiency, because the private cost of energy is less than the social cost. Governments have implemented a wide range of policies encouraging or mandating individuals, firms and government agencies to use more energy efficient products.

Transactions costs that in principle should be considered include:

- the costs of obtaining and processing information
- the opportunity cost of management or consumers' time in making decisions. When combined with the often low share of energy in firms' or consumers' costs, this may lead to simple decision rules (rules of thumb) that fail to optimise the use of energy, but economise on other scarce resources
- borrowing costs to finance investment in energy efficiency. These can be increased by the uncertainty of the costs and benefits of some energy efficiency investments (for example, in heterogeneous assets like buildings) and the capital constrained position of some consumers such as first home buyers or low income earners
- the costs of administering and complying with regulatory interventions. These costs are likely to be higher and more difficult to estimate where there are many small impact policies spread across all tiers of government. They will also generally be higher if there are inter-jurisdictional differences in policies within a country.

The cost of overriding consumer preferences is a highly contentious area. At its simplest, this can be conceived of as the loss of other valued product attributes. These might be overridden by regulation (for example, light quality of incandescent light globes) or forgone because of the higher initial capital cost of achieving greater energy efficiency. At a more complex level again, costs can depend on whether consumers and firms are correctly perceiving the costs and benefits of investing in durable goods that will save them energy relative to the counterfactual (box 3.4).

All of these costs would ideally need to be estimated in order to determine the costs of emissions reductions achieved through energy efficiency policies.

Private costs and benefits can also be difficult to identify because energy efficiency attributes are embodied in products and are difficult to disentangle from other product features.

Multiple policy objectives

In some cases, improved energy efficiency (often in conjunction with energy conservation) and the concomitant reduction in greenhouse gas emissions, is only one of a number of benefits justifying a particular policy. For example, a number of countries include improving energy security as an important objective of energy

efficiency regulations. Also many jurisdictions include achieving energy and emissions savings in transport as a consideration when framing air pollution, public transport and land use planning policies. In such circumstances, the private benefits and emissions-reduction gains, if they could be reliably estimated, could both be included in policy evaluation.

However, it is usually very difficult to disentangle the precise impacts on policy of these sometimes competing objectives, and the costs and benefits involved. Only if specific allowance were made in policy development for the value of greenhouse gas emissions savings, and that allowance led to defined additional expenditure or costs, could they be considered an identifiable and quantifiable abatement measure. For example, urban planning policies involve many competing and at times conflicting priorities, among which energy usage (and by implication emissions reductions) is only one.[4]

Whilst it is usually not feasible to precisely allocate policy costs across these various objectives, part of the costs of achieving abatement can be attributed to them.

C.3 Energy efficiency policies in electricity consumption

Chapter 4 presents a quantitative analysis of a number of measures directed at influencing the technologies used to generate electricity in favour of lower emissions sources. In addition to these measures, abatement policies in many countries have also focused on improving the energy efficiency of a wide range of household, business and government energy applications. Most of these relate to electricity. A large number of diverse policies have been used. This section provides an overview of several of the more important ones adopted in study countries.

Energy efficiency labels for appliances

There is a long history of information programs directly targeting perceived deficiencies in energy efficiency information on more energy intensive appliances and equipment. All study countries have some form of (usually mandatory) appliance labelling policy covering a range of consumer, commercial and in some

[4] In other cases impacts on energy efficiency are a coincidental outcome of particular policies. For example fuel standards and engine design regulations to reduce urban air pollution from motor vehicles will often reduce energy efficiency.

cases industrial products. Rating standards differ somewhat between countries. Sometimes mandatory schemes are supplemented by voluntary government sponsored labels, while in some countries private organisations provide endorsements or voluntary labels for energy efficient products (for example, the Energy Saving Trust in the United Kingdom).

The *United States* introduced a labelling scheme for appliances in 1980. The mandatory scheme now covers 11 products while the voluntary Energy Star label is used on around 20 others. The *European Union* (incorporating the *United Kingdom* and *Germany*) has had a mandatory labelling scheme since 1992 now covering 10 household appliance categories and has a voluntary Eco Label scheme used on 9 more. *Japan* has had a voluntary labelling system since 2000 applying to 16 household appliances.

South Korea has operated a compulsory labelling and standards program since 1992, that now covers 24 products. There is also a government sponsored high efficiency appliance certification program covering over 40 items of commercial and industrial equipment. *China* has voluntary energy labels for over 40 products and a compulsory label which commenced in 2005 and now covers around 20 products. *India* commenced a voluntary labelling program for frost-free refrigerators and tubular fluorescent lamps in 2006. Labelling for those products is now mandatory along with air conditioners and distribution transformers. There is voluntary labelling for several other products.

Australia has had a national mandatory energy efficiency labelling scheme since 1999, following more than a decade of individual state based labels. It now covers a range of major electrical and gas household appliance groups. The IEA (2010j) noted the very high compliance rates achieved by the scheme. In addition, Australian governments have developed an energy rating web site to provide information for consumers seeking an energy efficient appliance. *New Zealand* commenced mandatory labelling in 2002 and sets its standards in conjunction with Australia.

Minimum energy performance standards (MEPS) for appliances

All study countries have implemented some form of MEPS for new appliances — in general prohibiting the sale of appliances which do not meet these minimum standards. In some countries particular product types, such as incandescent light globes are banned altogether. In all countries, the level of the standards and the number of products covered have been increasing over time, including the coverage of some products used in the commercial and industrial sectors.

The *United States* has a long record of MEPS commencing, in the 1970s when energy security first became a major concern. The first federal standards were introduced in 1987. Initially 13 household appliances were covered and the number of products (now around 40 and including some commercial sector appliances) and the minimum performance standards have both increased over time. Several states impose standards on additional products. Initially the *European Union* was inhibited in introducing MEPS by the need for EU wide agreement to avoid obstructing EU trade. However, since 2005 it has implemented a number of MEPS and is in the process of significantly increasing the minimum allowable energy efficiency performance of many appliances.

Japan has energy efficiency standards covering over 20 household and commercial products. However, rather than setting minimum standards, each manufacturer and importer is required to achieve a designated weighted average energy efficiency performance for given appliance categories by a target year. These standards are set by reference to the product with the highest energy efficiency performance ('top runner') in the market in the base year — hence individual products are not prohibited from sale. Intermittently these standards are raised to reflect rising levels of achieved energy efficiency. Penalties for failing to achieve the average standard are light, with moral suasion and negotiation being preferred. *South Korea* commenced MEPS in 1992 and they now apply to over 20 household and commercial products.

China has an extensive program of MEPS which commenced in 1989 and now covers over 20 categories of residential, commercial and industrial appliances and equipment. Zhou (2008) considered that these standards, in conjunction with product labelling, had an important impact in reducing energy consumption, but that compliance had been a major problem. *India* commenced MEPS in 2007 with standards starting at a relatively low level but gradually being ratcheted up.

Australia first introduced national MEPS for various residential and commercial appliances in 1999, many evolving from earlier state-based standards. Australia and New Zealand now adopt the same standards for around 20 electrical and gas product groups. There are plans to further increase the product coverage and minimum standards. The Prime Minister's Task Group on Energy Efficiency (2010, p. 185) noted that Australia has 'a strong reputation internationally' for its current MEPS.

Unlike many of the motor vehicle fuel efficiency standards discussed below, MEPS have often been set significantly above the performance of the lower performing products in a number of countries (including Australia) and minimum standards have been raised over time. While rebound effects will have somewhat reduced their impacts, these policies are likely to have led to significant reductions in energy

use and greenhouse gas emissions in most countries. The costs of achieving this abatement are unclear. Policy development and implementation costs for government and business, particularly of the more intrusive MEPS, are generally difficult to estimate. Further, net costs (or benefits if the standards corrected market failures) to consumers of mandatory standards — which have restricted the options available to consumers by removing some lower priced products from the market, or leading to energy efficiency technology being incorporated at the expense of other product attributes — are problematic.

Energy performance standards for buildings

All study countries regulate the energy efficiency of new residential and commercial buildings. The level and extent of standards vary between countries and for different climatic regions within countries. In some cases (for example, Australia, the United States and India) they are imposed and/or regulated by sub-national levels of government, with varying degrees of coordination at the national level. In *Australia* they can also involve water efficiency measures as well. A number of countries (including Australia, the United Kingdom and Germany) now require disclosure of the energy performance of houses and commercial buildings at the time of sale or lease, to increase the previously limited information available about a building's energy efficiency.

Mandatory building energy codes in the *United States* were initially stimulated by energy security concerns following the 1970s oil crisis. Energy efficiency regulations for houses and commercial buildings are regulated at a state and local level with significant variations between jurisdictions, partly due to climate. Over time, standards have been implemented in more states and become more stringent in an effort to reduce greenhouse gas emissions, although a number of states still have no energy standards. There are also various model standards and codes developed by the federal government and private organisations, which can be adopted by the states or used by builders to inform buyers or renters about the energy efficiency and other attributes of a building.

In 2002 the *European Union* directed member states to set standards for the energy efficiency of new buildings and to update these regularly. Individual countries have responsibility for implementing this direction but requirements must be updated at least every five years. In the *United Kingdom*, energy efficiency requirements for insulation of new homes were first introduced into building regulations in 1965 and have been tightened several times since then and expanded to cover commercial buildings. Regulations were expanded and tightened in 2006 and further increases in standards are proposed. *Germany* first introduced insulation standards for new

buildings in the 1970s with ongoing increases in the stringency and coverage of energy efficiency requirements since then. The IEA (2009c) noted that German standards for new buildings were the highest in the G8 countries and further increases of over thirty per cent over current levels were in prospect.

Japan introduced energy performance standards for commercial buildings in 1979 and housing in 1980 and these have been strengthened over time to match European and US cold region standards. Although technically voluntary, they contain 'name and shame' provisions for larger projects (more than 2000 square metres) and monetary penalties since 2008. Hong et al. (2007) report compliance rates of 32 per cent for residences and 74 per cent for commercial buildings in 2004. For smaller buildings, standards are not mandatory and there are no penalties for non-compliance. *South Korea* first implemented mandatory energy efficiency standards (insulation thickness) in 1977 and standards were gradually expanded to cover various commercial and residential buildings. It formally adopted a mandatory building energy standard for larger commercial buildings and residential complexes in 2004, based on the Japanese model.

China has a history of province-based building standards and codes to improve energy efficiency in particular provinces, starting with housing in northern China in 1986. Standards were established for tourist hotels in 1993 and later for commercial and government buildings and for retrofits. However, Kang and Wei (2005) suggested that only 6 per cent of new buildings comply with the standards. Since 2008, China has required all provincial governments to increase urban energy efficiency in buildings and public transportation to meet energy intensity goals. The central government now audits local government plans. Chmutina (2010) noted that energy efficiency performance of the Chinese commercial building stock was much poorer than in developed countries.

Until 2007 there were no national energy efficiency requirements for new buildings in *India*. Mandatory energy efficiency standards have now been introduced for larger energy using commercial buildings and these are recommended for all other buildings. As there is a significant amount of new building in both China and India, standards will apply to a relatively greater percentage of the total building stock than in developed countries. The low per capita income of both countries suggests that the non-regulated level of energy use and energy efficiency in a building is likely to be lower than in developed countries. Hence any given standard of energy efficiency would tend to require a relatively greater increase in costs compared to business as usual.

New Zealand's Building Code provides minimum standards (which are reviewed over time) for energy use for heating, ventilation and cooling and lighting of

commercial buildings and for the energy performance of homes. As with appliances, the relatively small share of fossil fuels in electricity generation will limit the abatement benefits of these standards and increase the unit costs of abatement.

In *Australia*, mandatory building energy efficiency standards for new houses were introduced into the national building code in 2003. A number of jurisdictions had previously included energy efficiency standards in their building codes. These standards have since been extended to all new residential buildings and for commercial building and for major renovations, sometimes in conjunction with water saving and other environmental measures. Standards vary between climatic regions and some jurisdictions have continued to impose additional or alternative energy efficiency regulations. Development approval is only given when compliance is proven. The standards have increased over time, with further periodic tightening likely as part of an ongoing review process.

The wide variety of climatic zones covered by the study countries makes cross-country comparisons of standards difficult. In particular, Australia has only a small proportion of its population living in areas with extended periods of extreme climate, so that investments in energy efficiency standards would generally give lower returns. Also, because of the heterogeneous nature of residential and, particularly, commercial buildings, it is difficult and potentially expensive to accurately assess the costs and benefits of energy efficiency standards. In addition, the usage patterns of individual occupants will significantly affect the outcomes. The Commission has noted previously that it is difficult to assess both the impact on emissions and the costs of energy efficiency codes (PC 2005).

Furthermore, these uncertainties would be one explanation of the apparently high discount rates consumers and firms place on some investments in building energy efficiency.

Energy efficiency reporting requirements for large energy users

In recent years, a number of countries have implemented energy efficiency regulations directed specifically at the largest energy users, often requiring large energy using companies to undertake energy efficiency audits. The objectives are usually to encourage the businesses concerned to seek out further energy efficiency improvements and to provide demonstration effects for other energy users.

Japan requires designated energy management factories (annually using more than 3000 kL of fuel or more than 12 GWh of electricity) to follow energy rationalisation guidelines, prepare an energy rationalisation plan and appoint a number of licensed

energy managers. Compulsory energy audits are also undertaken (free for smaller companies) and the results monitored. In *South Korea*, businesses with annual energy use of more than 2000 tonnes of oil equivalent must conduct an energy audit every five years. Audits for smaller and medium-sized enterprises in this group are subsidised.

China set energy saving targets for 2005 to 2010 for 1000 enterprises consuming more than 5.3 petajoules per year (Top 1000 program), based on achieving energy efficiency improvements. The chosen enterprises' average annual energy consumption was 19.6 petajoules. Energy conservation agreements were signed between the firms and local governments, with both parties being held accountable for their achievement. Agreed savings averaged around 15 per cent (Price, Wang and Yun 2008). In *India*, companies in certain energy intensive sectors provide information in their annual reports on energy use and energy savings undertaken.

Australia has an Energy Efficiency Opportunities program, that since 2006 has required large energy-using corporations (those using more than 0.5 petajoules of energy per year) in all sectors of the economy to undertake energy efficiency opportunities assessments every five years and publicly report on the outcomes including annual updates. Over 200 corporations incorporating around 1200 subsidiaries are affected. Verification of compliance is undertaken for a sample of corporations. Decisions on undertaking identified opportunities are at the discretion of the business. Some state governments also have energy auditing requirements, sometimes in conjunction with other environmental goals. For example, in Victoria, all commercial and industrial sites that use more than 100 terjoules of energy or 120 ML of water in a financial year are generally required to prepare environment and resource efficiency plans and must implement all actions that have a three year or better payback period. These firms are subject to ongoing monitoring and reporting requirements. Queensland and New South Wales both have energy efficiency audit and reporting requirements for certain large energy users.

New Zealand has far fewer large energy using firms than other study countries. It provides subsidies up to NZ$10 000 or NZ$20 000 (up to one-third of the cost) for energy efficiency audits for businesses, truck fleets and building designs where relatively large energy use is involved. Recipients must commit to developing an action plan from the audit.

Very large energy users might be expected to have already identified profitable opportunities for energy efficiency improvements in the normal course of business. However, by mandating such studies, these programs may help to identify more marginal gains or bring forward improvements that would have been identified in the future. It is problematic what part of energy savings identified by mandatory

audits could be attributed to the existence of the programs and whether these savings justify the costs involved. In countries with some form of carbon tax, additional incentive to uncover and act on energy efficiency opportunities is provided by the tax.

In summary, Australian governments at all levels have implemented a wide array of regulatory policies designed to encourage or mandate improvements in energy efficiency in the use of electricity by households, business and government. While the breadth of policies used internationally makes it difficult to make comparisons with overseas countries, this suite of programs appears to broadly match those of other developed countries and generally surpasses that of developing countries.

C.4 Road transport

Chapter 5 examined quantitatively a range of fuel policies aimed at generating emissions reduction in the road transport sector. Several regulatory policies focusing on increasing the energy efficiency of new passenger motor vehicles, along with motor vehicle ownership charges, are considered below.

Provision of fuel efficiency and emissions information

One potential cause of sub-optimal motor vehicle purchasing decisions is that buyers might not possess sufficient knowledge to make an informed choice, despite information on the attributes (including fuel efficiency) of motor vehicles being available from a wide range of sources including automobile clubs, motoring magazines and vehicle producers. Nonetheless, many countries — including all study countries — have regulation or voluntary agreements for point-of-sale display labels showing fuel consumption, and in many cases carbon dioxide emissions, for new motor vehicles.[5] Fuel and carbon dioxide emissions are estimated using designated laboratory testing procedures, which often differ between countries and have also changed over time in some countries. A number of countries (for example, the *United States*, the *European Union* and *Japan*) are introducing compulsory fuel efficiency labelling for tyres.

[5] Several countries also have web-based facilities to assist buyers in comparing fuel efficiency between vehicles. In Australia, the Department of Climate Change and Energy Efficiency's Green Vehicle Guide provides a low cost convenient means for buyers to compare fuel efficiency and emissions performance of new passenger motor vehicles. A Truck Buyers Guide gives advice to businesses on how to choose a small truck which is more fuel efficient, while still suiting their needs. Consideration is being given to including fuel consumption and emissions data in vehicle advertisements.

These schemes are relatively low cost for government, vehicle producers and consumers and they directly address any information market failure relating to efficiency in the light vehicle market. They allow buyers to incorporate more precise comparative fuel efficiency and carbon dioxide emission information into their purchasing decision. As consumer preferences are not overridden, these measures do not generate any loss of consumer surplus. Nonetheless, there is a possibility that by providing explicit information on only energy efficiency and emissions, the labels may detract from buyers' relative consideration of other vehicle attributes. If these attributes are inversely correlated with energy efficiency, buyers may be encouraged to make sub-optimal decisions.

Australia has made similar efforts to most other developed countries in directly addressing any information deficiencies with regard to fuel efficiency, through labelling schemes and vehicle guides.

Vehicle fuel efficiency standards

Passenger motor vehicles account for a significant share of greenhouse gas emissions — globally, light-duty vehicles contribute around 12 per cent of energy-related emissions. This has led many countries to implement regulations or voluntary agreements with vehicle producers aimed at increasing the fuel efficiency of the new vehicle fleet. The major policy in this area has been establishing minimum fuel efficiency standards for the new car sales of individual motor vehicle manufacturers. The underlying engine efficiency of motor vehicles has increased significantly over the last twenty years. However, in response to consumer preferences, a trend towards vehicles with more energy-using equipment, and in some cases larger and faster vehicles, has limited the improvement in observed fuel efficiency in many countries. Australia's experience has been somewhat contrary, in that the gradual removal of very high levels of industry protection over the last 20 years has allowed smaller, more fuel efficient, imported vehicles greater access to the market and to significantly increase their market share.

The *United States* first imposed fuel efficiency regulations for new passenger vehicles and light trucks (pickups, minivans, sports utility vehicles) in 1978 for reasons of energy security. These were in the form of a common Corporate Average Fuel Economy (CAFE) target for each producer's new vehicle sales — for passenger cars starting at 18 miles per gallon (mpg) (13.1 litres per 100 km (L/100km)) in 1978 and rising to 27.5 mpg (8.6 L/100km) by 1985, where it remained largely unchanged for over 20 years. Fines apply to vehicle producers that

do not meet the standards.[6] In 2007 significantly higher standards were established for 2020.

However, new standards are now to apply from 2012 (around 33 mpg — 7.8 L/100km for cars), with the previous 2020 fleet-wide standard being brought forward to 2016 (39 mpg for cars and 30 mpg for light trucks — averaging about 35 mpg for the whole fleet). An emissions standard, largely consistent with the fuel efficiency standards, of 250 grams of CO_2 per mile for the vehicle fleet has been set for 2016. Also each model will now have a separate target, which then converts to a different sales weighted target for each producer. The inclusion of emissions as well as fuel efficiency standards should improve the cost effectiveness in achieving the abatement objectives underlying the policy.

While the standard has been surpassed for the national new fleet as a whole, some overseas producers have sometimes not met it and have paid large fines. Goldberg (1996) and Anderson et al. (2010) considered that the CAFE standards had been binding on automobile producers. However, it is not clear how significant that impact was. In the 1970s, consumers had already begun demanding more fuel efficient new vehicles in response to higher oil prices and concerns about energy security — actual new fleet fuel efficiency had risen from 13 mpg in 1973 to 20 mpg in 1978. In the meantime, standards did not increase after 1985, in which time Knittel (2009) argues that nearly all improvements in fuel efficiency technology were used by US producers to increase power and weight without sacrificing fuel efficiency, suggesting a long-running consumer preference for these features.

Costly market distortions which may have been caused by the CAFE program include favouring a shift in production of larger vehicles towards sports utility vehicles (classified as light trucks) (Anderson et al. 2010), distorting the choice between import and local manufacture of both small and large vehicles (Goldberg 1996) and possible increases in road fatalities through effects on vehicle fleet composition (Klier and Linn 2011). A variety of studies (including Green 2010, Parry, Evans and Oates 2010 and Bento, Li and Roth 2010) highlight the considerable uncertainty about whether the CAFE standards have provided net benefits to consumers.

The increases in the standards by over 40 per cent by 2016 is more likely to involve capital costs that buyers would not otherwise have incurred, but will also provide future savings in fuel expenses.

6 US$5.50 per tenth of a mile per gallon (A$5.32) under the standard for each vehicle manufactured for that year. Since the inception of the scheme importers have paid over US$500 million in fines.

The European Union and Japan have traditionally had the tightest international vehicle fuel efficiency and lowest carbon dioxide emissions targets, partly reflecting an existing market preference for fuel efficient vehicles and smaller cars. In 1998, the European Union (including the *United Kingdom* and *Germany*) established an industry wide average voluntary target with vehicle manufacturers and importers on the emissions of new vehicles of 140 grams of carbon dioxide per kilometre (g CO_2/km) (fuel efficiency of around 6.1 L/100km) by 2008. This was not achieved — actual fleet-wide emissions were over 155 g CO_2/km (6.7 L/100km) with wide variations between manufacturers. Now a mandatory average fleet emissions target of 130 g CO_2/km (equivalent to fuel use of around 5.6 L/100km) for passenger vehicles for each producer by 2016 will be phased in from 2012.[7] The 2016 standard for light commercial vehicles is 175 g CO_2/km.

Japan first applied corporate fuel efficiency targets for new passenger vehicles from 1985. Energy security objectives were part of the rationale for the policy. The most recent targets for various models equated to around a 6.7 L/100km fleet-wide average fuel efficiency for petrol vehicles in 2010. There were substantial tax savings on vehicles exceeding the standards before the 2010 target. In 2007, targets were set for 2015, based on nine weight classes. These were based broadly on the fuel efficiency of the best vehicle in class in the base year. The various targets equate to around a 6 L/100km fleet-wide average fuel efficiency (equivalent to emissions of about 125 g CO_2/km)[8]. Targets are mandatory but monetary penalties for not meeting them are small. In 2006, Japan introduced fuel-efficiency standards for heavy trucks, requiring a 12 per cent improvement by 2015.

Following earlier voluntary programs, *South Korea* introduced mandatory corporate fuel efficiency standards for domestically manufactured new car sales in 2006 and in 2009 for importers with sales of less than 10 000 vehicles per year. Importers selling more than 10 000 vehicles were subject to US CAFE standards. The standard for vehicles under 1500 cc was about 8 L/100km and 10.4 L/100km for those over 1500 cc. Further reductions were targeted for 2012 and a 2015 corporate carbon dioxide emissions standard has now been set of 140 g CO_2/km.

In 2005, *China* became one of the first developing countries to introduce fuel efficiency standards for domestically produced new light vehicles, with standards made about 10 per cent more stringent in 2008. Standards apply for 16 vehicle

7 Penalties apply of €5 per vehicle (A$7) for the first gram over the standard up to €95 (A$130) for the fourth gram onwards.

8 Because Japan has a much lower percentage of diesel vehicles than Europe, a given emissions target translates into a lower equivalent fuel efficiency target — diesel has both a higher energy content and carbon content.

weight classes and two transmission types and are applied to each model produced. Models not meeting the standard cannot be sold. These standards are only surpassed by the European Union and Japan. Imported vehicles which tend to be larger and more luxurious were not subject to the fuel efficiency regulations. The regulations have energy security and industry policy objectives as well as achieving emissions reductions. This adds to the difficulty in ascribing costs of the policy to carbon dioxide abatement. Oliver et al. (2009) considered that the standard did encourage producers to include more fuel efficiency technology in vehicles sold on the Chinese market but probably at somewhat higher prices.

India is developing a compulsory fuel efficiency standard for carbon dioxide emissions (in the range of 130 to 140 g CO_2/km) to be applied to the new car sales of each vehicle manufacturer and importer by 2015.

New Zealand considered a compulsory fuel efficiency standard for new and used light vehicles entering the fleet, but chose not to implement it because costs to motorists (up to NZ$1500 (A$1200) for a large car) would have outweighed the benefits.[9] However, it had set an average emissions objective for new and used vehicles entering the fleet in 2015 of 170 g CO_2/km. This objective is to be supported by information provision, incentives and capability building. New Zealand also has an emissions trading scheme that will encourage greater fuel efficiency and fuel conservation for the whole vehicle fleet.

Australia has had a voluntary industry-wide average fuel consumption target for new passenger petrol motor vehicles since 1978, when measured fuel consumption of the new fleet averaged around 11 L/100km. Various gradually reducing voluntary targets were negotiated over time with the industry, the latest being 6.8 L/100km by 2010.[10] In 2005, the vehicle industry committed to its own voluntary 2010 carbon dioxide emissions target of 222 g CO_2/km averaged across all new vehicles under 3.5 tonnes. The target was achieved in 2009. The government has now announced that a mandatory fleet-wide carbon dioxide emissions target will be set for 2015 with individual vehicle producers being given regulated targets. Carbon dioxide emission levels of 190 g CO_2/km by 2015 and 155 g CO_2/km by 2024 have been given as the starting point for further consultation with stakeholders. A Regulatory Impact Statement is to be prepared examining the implementation of this standard.

9 Conversion of foreign currency values to Australian Dollars (A$) in this appendix used average exchange rates over January to April 2011 (RBA 2011).

10 Changes in test procedures and vehicle coverage in 2003 significantly increased measured fleet fuel consumption by over 10 per cent and, along with the failure to proceed with the anticipated introduction of more energy efficient petrol, have made the 2010 target redundant.

Historically, outcomes have been generally slightly over the targets. Although average fuel efficiency of the new vehicle fleet has increased substantially (around 33 per cent) over the last 30 years, the Australian Transport Council (ATC 2009) found no evidence that the targets have had any influence on this. As the targets were voluntary and no individual producer was responsible for achieving them, there seems little incentive for individual producers to deviate from their 'business as usual' plans for fuel efficiency. Some of the improved fuel efficiency technologies incorporated in new vehicles sold in Australia may have been stimulated by overseas regulatory standards.

Until recent years, Australia's regulation of new motor vehicle fuel efficiency appears to have been in line with the relatively non-intrusive approach of a number of other study countries, although the fuel consumption targets were higher than in the (previously voluntary) European and (light-handed) Japanese schemes. However, the significant cross-country variations in scheme design, specification of standards and testing methods, and the difficulty in establishing non-regulatory counterfactuals would make any comparisons of 'relative effort' particularly imprecise. A number of countries, including Australia, have now announced significant increases in their fuel efficiency targets for 2015 and beyond, with a trend towards focusing on carbon dioxide emissions.

The effective stringency of standards expressed in fleet-wide terms, will depend partly on underlying consumer preferences in the country concerned. In European countries and Japan, which have high petrol taxes and are densely populated, with high levels of urban traffic congestion in many cities, preferences tend to be towards smaller, fuel efficient vehicles. Similar preferences exist for less wealthy countries like China, India and South Korea. In large, wealthy and less densely populated countries with relatively low petrol taxes, like the United States and Australia, bigger and more powerful cars have a much higher market share.[11] Hence, any given fleet-wide fuel efficiency standard will be more difficult and costly to attain and will generate relatively more emissions reduction in such countries.

Also, in the absence of substantial market failures, the cost of abatement imposed by fuel efficiency standards for new vehicles can be unnecessarily high. All of the abatement burden is placed on new vehicles — no ongoing incentives are in place to improve fuel efficiency of older vehicles, to update to more fuel efficient

[11] The Federal Chamber of Automotive Industries (FCAI 2010) noted that the combined small/medium vehicles sector held similar market shares in Australia as in Germany and the United Kingdom. However, large cars held nearly a quarter of the market in Australia compared to 8 per cent in Germany and 5 per cent in the United Kingdom. Conversely, the share of light vehicles was much lower in Australia.

vehicles, use less polluting fuels or reduce kilometres travelled.[12] Also, by further increasing the up front capital cost of new vehicles, higher fuel efficiency standards can discourage upgrading to new (usually already more fuel efficient) vehicles thereby increasing emissions. Hence achieving emissions reductions by simply emulating increasing overseas fuel efficiency standards may involve unnecessarily high costs. For example, *New Zealand* has chosen not to implement fuel efficiency standards for new motor vehicles, but rather will achieve transport emission abatement more efficiently by including transport fuel in its emissions trading scheme.

Vehicle charges related to fuel efficiency

Some taxes on vehicle ownership have provided incentives (often coincidentally with primary policy objectives) to purchase more fuel and/or emissions efficient vehicles, although often the relationship is only loose via vehicle weight or engine size. A number of governments have now more closely aligned these taxes to fuel efficiency or emissions.

- Since 1978 the *United States* has had a 'gas-guzzler tax' which is an excise on manufacturers of new passenger cars that fail to meet a minimum fuel efficiency standard (currently 22.5 mpg). The tax increases as tested fuel efficiency decreases. However, it does not apply to light trucks including sports utility vehicles. Vehicle registration fees (usually annual) are charged on a state and even county basis. Some are flat fees, while others vary with a vehicle's weight, age or value.
- In the *United Kingdom*, first year registration tax and annual vehicle tax are both based on a vehicle's rated CO_2 emissions (13 steps from 100 to over 255 g CO_2/km). First year registration ranges from zero to £950 (A$1489) and annual fees from zero to £435 (A$682).
- *Germany* has annual ownership taxes for vehicles based on a combination of engine size and rated carbon dioxide emissions — the latter increasing in a continuous fashion once emissions go over 120 g CO_2/km.
- In *Japan*, the vehicle acquisition tax rises step wise with engine size, as does an annual automobile tax, while there is also an annual tonnage tax per 500 kilograms of vehicle weight.

[12] The United States and Germany both introduced a temporary 'cash for clunkers' program in 2009. These schemes provided subsidies for scrapping older vehicles to purchase new ones, in order to stimulate the economy during the global financial crisis. Such a scheme was also proposed for Australia, but was abandoned prior to being implemented.

- In *South Korea*, vehicle taxes are based on engine size, but consideration is being given to switching to a fuel efficiency or carbon dioxide emissions-based system.
- Excise rates on new vehicles in *China* vary in a step-wise fashion with engine displacement. In addition, vehicles with engine displacement of 1.6 litres or less, and which meet fuel efficiency standards, received a subsidy of CNY 3000 (A$443).
- *India* levies excise on vehicles, which varies by vehicle class, and a special duty which increases in three steps with engine displacement.
- *New Zealand's* initial registration fee and annual vehicle licences are largely invariant to vehicle size or fuel efficiency. However, New Zealand includes transport fuels in its emissions trading scheme.
- In *Australia*, annual registration fees and stamp duty on vehicle purchase are imposed by the States and Territories and are generally levied on the basis of weight, engine capacity or number of cylinders. In some cases, registration fees for passenger vehicles are fixed amounts while in others they vary with vehicle weight. Stamp duty varies with the price of the vehicle, usually with some broad stepwise rate increases for higher prices. In addition, the Australian Government applies a 'luxury car' tax (33 per cent) to the GST-exclusive price of a vehicle over a threshold value (around A$57 000). It does not apply to vehicles with rated fuel consumption below 7L/100km, which cost below A$75 375.

Some countries have taxes on vehicle purchase and ownership that vary directly with fuel or emissions efficiency while in others (including Australia), there is only a rather indirect (in varying degrees) relationship, via vehicle size or price. Australia's passenger motor vehicle manufacturing industry is more concentrated in the medium to larger cars, which tend to be less fuel efficient. Hence, vehicle taxes which favour more fuel efficient vehicles will tend to disadvantage domestic production.

Varying vehicle taxes according to estimated fuel efficiency or carbon dioxide emissions is an indirect and hence generally less cost-effective means of achieving emissions reductions. Unlike fuel taxes they do not provide incentives for abatement through mechanisms such as reduced vehicle use, more efficient driving practices and better vehicle maintenance. However, as the higher taxes are aggregated into relatively large up-front and annual lump sums, consumers may be more responsive to them.

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D Australia's electricity generation sector

The Commission's stocktake of emissions-reduction policies identified around 240 policies in Australia, at the Commonwealth and state levels. This appendix focuses on major emissions-reduction policies that directly relate to the electricity generation sector. Some transport polices (such as major biofuel policies and fuel taxes) are discussed and quantified in Chapter 5, while energy efficiency policies (including information programs) are examined in Appendix C. Research and development policies, land management and forestry policies and government procurement policies are not analysed in detail.

The Commission estimated the impacts of the following Australian electricity sector policies:

- the Renewable Energy Target (RET)
- solar feed-in tariffs (FITs)
- the NSW and ACT Greenhouse Gas Reduction Scheme (GGAS), and
- the Queensland Gas Scheme.

A number of other Australian electricity-sector emissions-reduction policies were considered, but not included in the analysis. In general, where policies were not included in the analysis, it was because the Commission considered that they were unlikely to make a material difference to the aggregate estimates (section D.9)

The policies have been evaluated for the 2009 or 2010 calendar year (depending on data availability). All estimates are expressed in 2010 dollars.

D.1 Electricity generation in Australia

Australia's electricity generation sector can be broken down into three systems:

- the National Electricity Market (NEM), which operates in the eastern states
- the Wholesale Electricity Market, which operates in Western Australia

- the Northern Territory, which is serviced by an integrated electricity utility.

The electricity transmission network for the NEM has interconnectors through Queensland, New South Wales, South Australia, Victoria and the Australian Capital Territory. There is also an undersea interconnector between Victoria and Tasmania. The electricity transmission networks in Queensland, New South Wales, the Australian Capital Territory and Tasmania are owned by state governments. In contrast, the transmission networks in Victoria and South Australia are privatised, while the interconnectors are also privately owned. The transmission network service providers are regulated by the Australian Energy Regulator.

The NEM operates as a mandatory wholesale pool under the management of the Australian Energy Market Operator. Generators sell their electricity into the pool and retailers (and some large users) buy electricity from the pool to on-sell to residential and business consumers. Around two-thirds of electricity generation capacity in the NEM is government-owned. Generators make bids to supply electricity into the pool at five-minute intervals, and bids are accepted in price order (lowest-price bids are accepted first, up to the point where supply is equal to demand). The 'dispatch price' for each five-minute interval is set equal to the price of the last bid needed to meet the demand at a given period, and the wholesale spot price is calculated every 30 minutes as the average of the 'dispatch prices' for the six five-minute intervals that make up the period. The maximum spot price is capped at A$12 500/MWh, while the minimum spot price is minus A$1000/MWh. Generators might offer negative bids if it is not possible (or costly) for them to switch off their supply. This can be the case for wind farms, and for some thermal plants (AEMO 2010a, Energy Supply Association of Australia 2010).

While most physical electricity is traded through the central pool, generators and retailers also enter into financial contracts to hedge against the volatility in the spot market. For example, a retailer may contract with a generator to effectively purchase electricity for A$40/MWh (the 'strike price') in a given period. If the NEM spot price in that period turns out to be above the strike price, the generator pays the difference to the retailer. If the NEM spot price is below the strike price, the retailer pays the difference to the generator. These trades are settled through cash payments rather than the physical delivery of electricity at the agreed price.

There is retail competition in most NEM regions with private retailers being the major players in Victoria, South Australia and Queensland. Some retailers are vertically integrated and also own generation capacity. The single retailer in Tasmania is owned by the Tasmanian Government. The regulation of retail electricity prices is a state government responsibility, and states have implemented a mix of regulations.

In Western Australia, the main electricity transmission networks — South West Interconnected System, North West Interconnected System and Esperance System — are owned by Western Power and Horizon Power, both state government trading enterprises. The networks are not connected to other states or the Northern Territory. In addition to conventional electricity generation, there is also isolated cogeneration in the Pilbara and other regions.

In the South West Interconnected System, most electricity is traded through bilateral contracts between generators and retailers. There is also a short-term energy market to provide electricity to balance supply and demand at short intervals. This market is operated by the Independent Market Operator. One difference between the South West Interconnected System and the NEM is that in Western Australia generators receive additional payments to provide capacity, irrespective of the amount of electricity they supply.

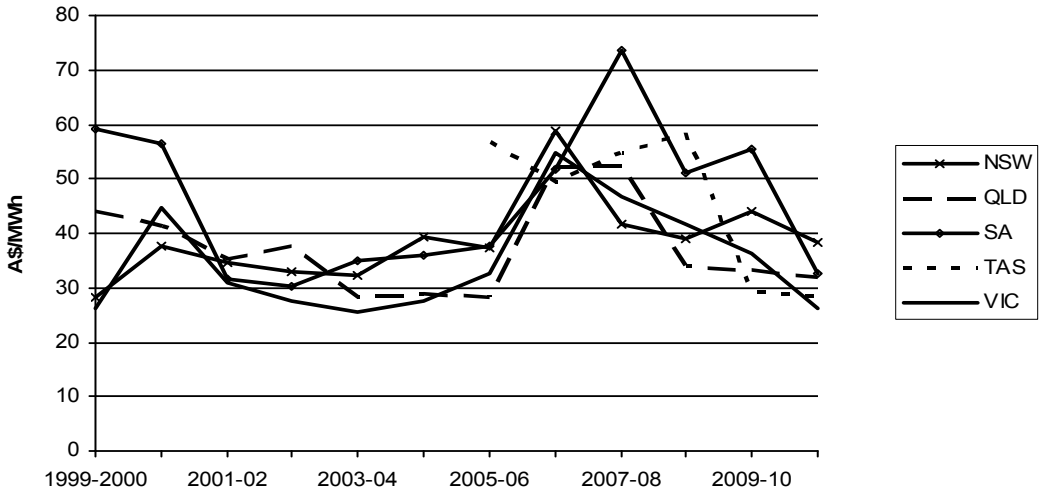
The Northern Territory system is operated by an integrated government utility that is responsible for generation, transmission and retail. As such, there is no competition in these sectors.

Key statistics

Wholesale electricity price

Wholesale electricity prices in the NEM regions vary, but over the period 1999–2011 exhibited similar trends (figure D.1). Average peak and off-peak prices in the regions have varied significantly over the first four months of 2011 (table D.1) (it should be noted that these data are likely to reflect seasonal factors, because they only cover the first four months of the year). Data on wholesale prices in Western Australia were not available (because most electricity is traded through bilateral contracts). However, in 2010, the average clearing price on the Western Australian short-term electricity market was around A$29/MWh. Data on prices in the Northern Territory were not available.

Figure D.1 **Average NEM wholesale electricity prices**
Australia, 1999–2011, Nominal prices



Source: AEMO (2011a).

Table D.1 **Average NEM prices**
Australia, January 2011 to April 2011

Region	*Daily average*	*Peak average (7am–10pm)*
	A$/MWh	A$/MWh
New South Wales	59	98
Victoria	33	45
Queensland	50	81
South Australia	46	76
Tasmania	27	29

Source: AEMO (2011b).

Fuels used in electricity generation

The majority of the electricity generated in Australia is derived from coal and gas. Hydroelectricity is the largest renewable energy source (table D.2).

Table D.2 **Electricity generation fuel use**
Australia, July 2008 – June 2009

Fuel source	*Total generation*	*Proportion of total*
	TWh	%
Black coal	143	55
Brown coal	57	22
Oil	3	1
Gas	39	15
Renewables		
Hydroelectricity	11.9	5
Wind	3.1	2
Solar	0.3	–
Biomass	1.5	1
Biogas	1.3	–

– nil or rounded to zero.

Source: ABARES (2011).

Emissions

In 2010, total emissions from the Australian electricity sector were 196 Mt CO_2-e (DCCEE 2011a). The emissions intensity of the fuels used to generate electricity in Australia varies significantly. The Commission has estimated the average emissions intensity of fossil-fuel generation in Australia using a weighted average based on 2010 plant-level emissions and generation estimates from Frontier Economics (unpublished data), and Australian electricity generation data from the Australian Bureau of Agricultural and Research Economics and Sciences for 2008-09 (table D.3).

Table D.3 **Average emissions intensity of electricity generation**
Australia, 2010

Fuel	*Emissions intensity (t CO_2/MWh)*
Brown coal	1.20
Oil	0.97
Black coal	0.92
Gas	0.54
Renewables	0.00
Australian coal average	**1.00**
Australian fossil fuel average	**0.92**

Sources: ABARES (2011); Frontier Economics (unpublished data); Productivity Commission estimates.

D.2 Abatement

In order to estimate the abatement attributable to various policies, the Commission has generally assumed that lower-emissions generation induced by the emissions-reduction policies displace a mix of fossil-fuel generation having an emissions intensity equal to the average emissions intensity of fossil-fuel generation in Australia (0.92 t CO_2/MWh). Using the Australian average may overstate the amount of abatement in Western Australia where there is a relatively large share of gas generation, compared with the NEM. For sensitivity analysis, the Commission used the emissions intensity of gas-fired generation in Australia (0.54 t CO_2/MWh) and the weighted average emissions intensity of coal-fired generation in Australia (1 t CO_2/MWh).

D.3 Policy overlaps

As noted, the Commission has estimated the subsidy equivalent associated with four policy groups. It is important to identify any overlaps, to ensure that abatement is not overestimated by attributing the same abatement to multiple policies. The Commission considers that:

- the Queensland Gas Scheme does not overlap with the other policies, because generators cannot receive credit under this scheme if they have received another subsidy
- retailers in New South Wales and the ACT can use renewable energy certificates (RECs) to meet obligations under both the GGAS and the RET. The subsidy provided by RECs is covered under the estimation of the RET, and is not considered in the GGAS section
- renewable generators do not create New South Wales greenhouse gas abatement certificates (NGACs) under GGAS. Therefore, there was no overlap between GGAS and the RET and FITs (other than those discussed above)
- generators receiving FITs in 2010 were eligible to receive RECs. Thus renewable generation covered under the FITs is already included in the analysis of the RET.

Taking these relationships into account, the Commission has estimated the total abatement attributable to the policies as:

- gas generation induced by the Queensland Gas Scheme
- abatement induced by NGACs created under GGAS
- renewable generation induced by the RET.

The FITs are unlikely to have led to any additional abatement in 2010, and thus only the subsidy equivalent (and not abatement or the implicit abatement subsidy) was estimated.

D.4 Renewable Energy Target (RET)

The Mandatory Renewable Energy Target was introduced in 2001, with the intention of encouraging additional renewable electricity generation. Under this policy, generators that supplied renewable electricity generally received one (or more) RECs for each MWh of renewable electricity supplied above baseline production over the period 1994–1997. These RECs were sold to electricity retailers, who were obliged to surrender a given number of RECs each year.

In 2009, the Mandatory Renewable Energy Target was replaced by the RET. The new system offered five RECs for each MWh of renewable electricity supplied by small-scale solar systems. In addition, RECs for small-scale solar systems were 'deemed' — RECs were allocated up front for the projected generation from solar systems over the next 15 years. In response to the solar multiplier and deeming, the number of RECs issued to small generation units went from around 350 000 in 2008 to 21 million in 2010. Small generation units accounted for almost two thirds of RECs issued in 2010 (ORER 2011c).

The influx of small-scale RECs into the market led to concerns that the REC price would be depressed, and there would be little incentive for generators to enter into long-term contracts to build new large-scale renewable plants. To address these concerns, the RET was divided into two programs in 2011 — the Large-Scale Renewable Energy Target and the Small-Scale Renewable Energy Scheme. Retailers must purchase a specified number of certificates from each of these schemes. The solar 'multiplier' is scheduled to decline over time, which will reduce the costs of the scheme.

It is important to note that the year being analysed in this section, 2010, was unusual both in terms of the number of RECs created and the composition, being sourced mainly through small generation units and solar water heaters.

While large-scale renewables and small-scale renewables were part of the same scheme in 2010, the analysis of these components was conducted separately here. This was due to the differences in the allocation of certificates to these two components — while large-scale renewables were granted certificates each year on the basis of actual generation, small-scale renewables were granted certificates up

front, on the basis of expected generation over their economic life (effectively a capital subsidy).

In addition, while solar hot water heaters are eligible to receive RECs under this scheme, they are not directly relevant to the electricity generation sector, and thus have been excluded from the analysis.

Large-scale Renewable Energy Target

Subsidy equivalent

The subsidy equivalent for the large-scale RET was estimated in a similar fashion to other renewable energy certificate schemes — the subsidy equivalent is given by multiplying the REC price by the number of certificates issued to *additional* generation.

The Commission has assumed that in this case all generation that receives certificates was 'additional'. Certificates under the RET are only issued for generation above a 1994–1997 average baseline. Therefore it has been implicitly assumed that all generation installed after this date was policy-induced. This is likely to lead to an 'upper bound' estimate of the subsidy equivalent and abatement, though evidence on the relatively high costs of building solar and wind plants would seem to support the conclusion that almost all solar and wind generation was policy-induced.

RECs are traded in two ways. The first is through long-term contracts between electricity retailers with REC obligations, and renewable energy generators. Typically these contracts have been 'power purchase agreements', where retailers agree to purchase electricity and the associated RECs from generators. These arrangements provide generators with a stream of revenue that they can use to obtain finance to build new plants (such as wind farms). The second way RECs are traded is through a 'spot' market, where RECs are traded separate from electricity. The Commission understands that the long-term contract price of RECs has historically been above the 2010 average spot price.

Historically, most RECs (around 90 per cent) created by large-scale projects have been traded through long-term contracts (AGL, pers. comm., 10 May 2011). This suggests that the relevant measure of the resource costs of large scale renewable energy projects is related to the contract REC price, not the spot price. Contract price data are not publicly available, so the Commission has estimated the contract REC price based on the cost of generating electricity using wind farms, and the

average wholesale electricity price. The Commission's estimate of the contract REC price for this analysis is A$60 per REC (box D.1). Estimates of the subsidy equivalent use this figure as an upper bound, and the average 2010 spot market REC price (A$37.03) as a lower bound.

There were around 28.6 million RECs issued in 2010 (excluding solar water heaters), of which 7.6 million were granted to large-scale generation. Therefore, the subsidy equivalent for the large scale component of the RET was estimated to be between A$283 million and $459 million.

Box D.1 **The Commission's estimate of the contract REC price**

Because data on long-term contract prices for RECs are not publicly available, the Commission has estimated the contract REC price that would need to have applied in 2010 to meet the additional costs of wind power (the most widely used large-scale renewable). The contract REC price was estimated as the long-run marginal cost (LRMC) of wind power minus the average wholesale electricity price.

The Commission has assumed that the LRMC of wind power is A$110/MWh. This is based on data from Frontier Economics (unpublished data) that suggested that the LRMC of wind power projects in Australia was mostly in the range A$100–A$120/MWh.

The average wholesale price of electricity was assumed to be A$50/MWh (section D.1). This implies that for wind power projects to meet their LRMC, the REC price would need to be around A$60.

This estimate was based on a number of assumptions, and could be an under or over estimate of the average contract price of RECs. As this estimation reflects the current levelised cost of wind, it may be more likely to be an overestimate, as contracts signed in previous years may reflect the cost of wind farms built in better sites.

Abatement

Since one REC was equivalent to one MWh of renewable generation (above the baseline) for the large generation component, the increase in renewable generation attributable to that component was estimated to be 7.6 TWh. For the 'central' estimate of RET-induced abatement, each MWh of renewable generation was assumed to displace one MWh of fossil fuel generation with an average emissions intensity of 0.92 t CO_2/MWh. Hence, the estimated abatement for the large-generation component was 7 Mt of CO_2.

Small-scale Renewable Energy Target

Subsidy equivalent

In the case of small-scale projects, the REC price used to estimate the subsidy equivalent was the spot market price, because most RECs generated by small-scale projects were traded through the spot market. In 2010, small-scale generators received 21 million RECs, and the average spot price of RECs was A$37.03. Therefore, the total outlay received by small-scale generators was A$777 million.

As noted above, small-scale generators received RECs up front, on the basis of expected generation over their economic lifetime. Therefore, the subsidy was essentially for abatement that will take place over a number of years, and as such the subsidy was converted into an annualised value. The economic life of the investment was assumed to be 20 years, and the real discount rate used was 7 per cent. Therefore, the estimated subsidy equivalent was A$73 million.

Abatement

The estimated abatement for the small-scale component of the RET was total generation in 2010 receiving the RECs, multiplied by a counterfactual emissions intensity.

In 2010, approximately 19.8 million RECs qualified for the solar multiplier of five. Hence, these RECs were only associated with 4 TWh of estimated renewable generation (=19.8 million/5). The 1.2 TWh that was associated with the small-scale component, but was ineligible for the solar multiplier can be added without further adjustment. Thus, the estimated future renewable electricity generation as a result of capacity augmentation under the small-generation component in 2010 was around 5.2 TWh.

However, since these certificates were granted up-front for generation, which was assumed to occur over a 15 year period, another adjustment was necessary to estimate the annual generation.[1] Thus, the estimated annual renewable generation induced under the small generation component was estimated to be 344 GWh (5.2 TWh divided by 15 years).

[1] The 15 year period is a policy parameter that reflects the policy assumptions about the number of years for which solar PV systems would be receiving RECs. This is different to the economic life of the investment, which is assumed to be 20 years, consistent with the assumption the Commission has used for other countries.

Using a counterfactual emissions intensity of 0.92 t CO_2/MWh, the abatement estimated to be attributable to the small-scale renewables in the RET was 317 kt CO_2.

Sensitivity analysis and implicit abatement subsidy

The implicit abatement subsidy for the RET depends on the assumptions used. The Commission has estimated the subsidy equivalent for the large-scale RET using REC prices of A$37.03 and A$60, and for the small-scale component using discount rates of 3, 7 and 11 per cent (real). Abatement was estimated using a range of counterfactual emissions intensities. The implicit abatement subsidy for the RET as a whole was estimated to be between A$42 and A$129/t CO_2 (with the large-scale component estimated at A$37–A$111/t CO_2 and the small-scale component estimated at A$152–A$525/t CO_2 (table D.4)

Table D.4 **Implicit abatement subsidy, Renewable Energy Target**
Australia, 2010

Component	*Subsidy equivalent*	*Abatement*			*Implicit abatement subsidy*
		Low	*'Central'*	*High*	
	A$m (2010)	Mt CO_2			A$/t CO_2
Large scale					
Lower bound (REC price = A$37.03)	283	4	7	8	37–69
Upper bound (REC price = A$60)	459	4	7	8	60–111
Small Scale					
7% discount rate	73	0.2	0.3	0.3	230–425
3% discount rate	52	0.2	0.3	0.3	152–281
11% discount rate	98	0.2	0.3	0.3	283–525
RET Total	**335–556**	**4**	**7**	**8**	**42–129**

Source: Productivity Commission estimates.

D.5 State and territory solar feed-in tariffs

All Australian states have solar feed-in tariffs (FITs) of some description. The first solar FITs were implemented by Queensland and South Australia in 2008, with other states following in 2009 and 2010 (table D.5). The Commission has analysed the impacts of FITs in all states and territories except Tasmania and the

Northern Territory. In both these cases, the Commission was unable to access the relevant data. However, the size of these jurisdictions means that their exclusion from the analysis is not likely to make a significant difference to the totals.

FITs are paid either on a net or gross basis. Queensland, Victoria, South Australia and Western Australia have net FITs, where people who have eligible solar generation systems receive a payment for the electricity they export to the grid. For example, suppose a Queensland household generates 10 kWh of solar electricity in a day, but only consumes 5 kWh. If the household exports the difference to the grid, it would receive a payment of A$2.20 (5 kWh multiplied by 44 cents per kWh).

New South Wales and the Australian Capital Territory have gross FITs, where people who have eligible solar generation systems receive a payment for all electricity they generate, irrespective of whether it is exported to the grid or used by the household. So if an ACT household generates 10 kWh of solar electricity in a day, and consumes 5 kWh in the home, the household would receive a payment for the full 10 kWh — A$4.57 (10 kWh multiplied by 45.7 cents per kWh).

The difference between gross and net FITs means that care has to be taken in comparing FIT rates between states, and has implications for calculating the subsidy equivalents.

Table D.5 **Solar feed-in tariffs by region**
Australia, 2010

Region	*Commenced*	*Rate*	*Type*
		c/KWh	
New South Wales	January 2010	60 for systems installed before 27 October 2010 and 20 for systems installed after[a]	gross
Australian Capital Territory	March 2009	45.7	gross
Victoria	November 2009	60	net
Queensland	July 2008	44	net
South Australia	July 2008	44	net
Western Australia	August 2010	40	net

a The analysis does not include changes to the NSW FIT scheme that were announced in May 2011. These changes would reduce the FIT payable to households that installed solar photovoltaic systems from 60 cents/kWh to 20 cents/kWh.

Source: APH (2011).

Subsidy equivalent

The Commission obtained data on the capacity of eligible solar generation that was installed at the end of 2010. However, the Commission was not able to obtain data

on generation from solar photovoltaic (PV) systems, or on when the systems were installed during 2010. Instead, for Victoria, Queensland and South Australia, the Commission has made the assumption that all capacity that was installed at the end of 2010 had been installed for the entire year. This is likely to overstate the generation from solar PV in these states in 2010, and as a result overstate the subsidy equivalent. The estimates should accordingly be treated as upper bounds.

In the case of New South Wales, the FIT rate changed during 2010. To account for this, the Commission has assumed that capacity was installed evenly throughout 2010. The Western Australia FIT only commenced operation in August 2010. To account for this, capacity was assumed to be installed evenly from the start of the program in August 2010 to the end of 2010.

Estimating subsidy equivalents for net FITs

The subsidy equivalent is equal to the production subsidy equivalent (φ) multiplied by the quantity of electricity that receives the FIT. In the states with a net FIT (Victoria, Queensland, Western Australia and South Australia) the production subsidy equivalent was estimated as the difference between the FIT and the daytime wholesale electricity price (daytime prices are used because solar PV systems generate electricity only during daylight hours). This captures the unit mark up over the price that households would receive for selling electricity to the grid without assistance:[2]

$$\varphi_{i,x} = FIT_i - p_i$$

The quantity of electricity eligible for FITs (q_i) was estimated using the installed capacity (c_i), the capacity factor (e_i) and the number of hours in a year (8760):

$$q_i = c_i * e_i * 8760$$

To calculate the subsidy equivalent, it was necessary to account for the proportion of electricity that was exported to the grid (x_i). The subsidy equivalent is then given by:

$$SE_i = \varphi_{i,x} * q_i * x_i$$

2 Implicit in this analysis is the assumption that in the absence of the FIT, households would be able to sell electricity into the grid and receive the wholesale price. This may not be a realistic assumption for all states. The net effect of this assumption would be to understate the subsidy equivalent to solar PV.

Variables are defined in table D.6, and estimated parameter values are reported in table D.7.

Table D.6 **Definitions**

Symbol	*Definition*	*Units*
$\varphi_{i,x}$	Production subsidy in jurisdiction *i* for electricity exported to the grid	A$/MWh
$\varphi_{i,d}$	Production subsidy in jurisdiction *i* for electricity used by the generator	A$/MWh
FIT_i	Feed-in tariff in jurisdiction *i*	A$/MWh
p_i	Average daytime wholesale electricity price	A$/MWh
q_i	Eligible electricity generation	MWh
c_i	Eligible generation capacity in jurisdiction *i* at the end of 2010	MW
e_i	Capacity factor (average annual generation per MW of capacity)	%
SE_i	Subsidy equivalent in jurisdiction *i*	A$
x_i	Export factor (proportion of electricity exported to the grid)	%
h_i	Number of hours the program was running in jurisdiction *i*	hours

Estimating 2010 solar electricity generation in Western Australia

The Western Australian FITs only commenced in August 2010. Hence, a different approach was needed to estimate the relevant generation in that state. In this case, estimated generation is given by:

$$q_i = (c_i * e_i * h_i) / 2$$

Estimating subsidy equivalents for gross FITs

Where gross FITs are paid, the subsidy equivalent consists of two elements: the subsidy for electricity exported to the grid, and the subsidy for electricity consumed by the generator. For the electricity that was exported to the grid, the subsidy equivalent was estimated in the same way as for net FITs. For the electricity that was consumed by the generator, the production subsidy equivalent is given by:

$$\varphi_{i,d} = FIT_i$$

Hence, the subsidy equivalent for states with a gross FIT is given by:

$$SE_i = [\varphi_{i,x} * q_i * x_i] + [\varphi_{i,d} * q_i * (1 - x_i)]$$

For the ACT, the quantity of electricity eligible for FITs was estimated in the same way as for Victoria, Queensland and South Australia. Because the FIT rates in New South Wales changed in October, a different approach was necessary.

Estimating 2010 solar electricity generation in New South Wales

The New South Wales gross FIT was 60 cents/kWh for systems installed before 27 October 2010 (FIT_1) and 20 cents/kWh for systems installed after (FIT_2). This implies that there were effectively four production subsidy equivalent rates during 2010:

$\varphi_{1,x} = FIT_1 - p_i$ production subsidy for electricity exported under FIT_1

$\varphi_{1,d} = FIT_1$ production subsidy for user-consumed power under FIT_1

$\varphi_{2,x} = FIT_2 - p_i$ production subsidy for electricity exported under FIT_2

$\varphi_{2,d} = FIT_2$ production subsidy for user-consumed power under FIT_2

In order to estimate the subsidy equivalent, the Commission has estimated how much generation was eligible for each FIT: q_1 is the amount of electricity eligible for FIT_1, and q_2 the amount of electricity eligible for FIT_2. The Commission has assumed that solar PV systems were installed at an even rate throughout the year. This implies that q_1 and q_2 are equal to the darker and lighter shaded areas in figure D.2 respectively. Formally, q_1 and q_2 are given by the following formulae:

$$q_1 = c_i * e_i * (h_1/8760) * (h_1/2 + h_2)$$

$$q_2 = c_i * e_i * (h_2/8760) * (h_2/2)$$

The subsidy equivalent is the sum of both components, exported and within household, for both tariffs.

$$SE = \{ [\varphi_{1,x} * q_1 * x] + [\varphi_{1,d} * q_1 * (1-x)]\} + \{[\varphi_{2,x} * q_2 * x] + [\varphi_{2,d} * q_2 * (1-x)]\}$$

Results

The estimated subsidy equivalents for 2010 range from A$2.2 million in Western Australia and the ACT to A$42.6 million in New South Wales (table D.8). The combined subsidy equivalent for all jurisdictions was around A$96 million.

It should be noted that on 13 May 2011 the New South Wales Government announced its intention to reduce the feed-in tariff rate for all solar receiving the New South Wales FITs to A$40/MWh. This would reduce the subsidy equivalent estimate. However, as of the time of writing, the details of this policy were unclear.

Figure D.2 **Stylised representation of electricity generation under the FIT in New South Wales**

Australia, 2010

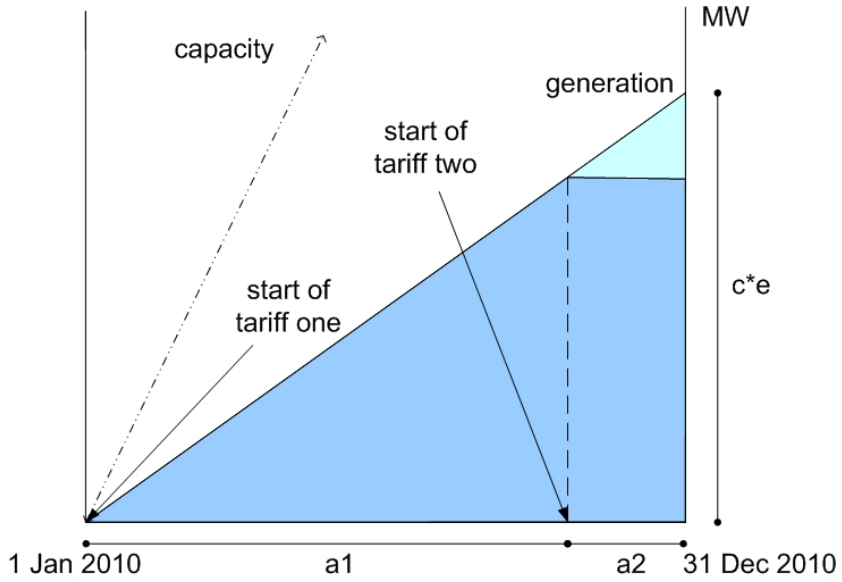


Table D.7 **Parameter values, feed-in tariffs**

Australia, 2010

Jurisdiction	*FIT*	*p*	*c*	*e*	*x*	*h*
	A$/MWh	A$/MWh	MW			hours
QLD	440	51.4	81.5	0.15	0.5	
NSW	FIT_1 = 600 FIT_2 = 200	73.1	117.6	0.15	0.5	h_1 = 7 200 h_2 = 1 560
ACT	457[a]	73.1	4.0	0.15	0.5	
VIC	600	45.2	61.6	0.15	0.5	
SA	440	100.9	27.5	0.15	0.5	
WA	400	35.3	44.2	0.15	0.5	3 672

Source: Frontier Economics (unpublished data); Productivity Commission estimates.

[a] Note that the rates in the ACT were A$501/MWh (for systems up to 10 kW) and A$400/MWh (for systems between 10–30 kW) for the first half of 2010. The Commission was unable to locate data on the generation receiving the different FIT rates, and therefore has assumed that the rate was equal to the FIT rate operating for all systems from 1 July 2010 — A$457/MWh.

Table D.8 **Subsidy equivalents, state feed-in tariffs**
Australia, 2010

Jurisdiction	φ_x	φ_d	q	*SE*
	A$/MWh	A$/MWh	GWh	A$m (2010)
Net FITs				
Victoria	555	..	81	22.5
Queensland	389	..	107	20.8
Western Australia	365	..	12	2.2
South Australia	339	..	36	6.1
Gross FITs				
New South Wales	$\varphi_{1,x}$ = 527 $\varphi_{2,x}$ = 127	$\varphi_{1,d}$ = 600 $\varphi_{2,d}$ = 200	q_1 = 75 q_2 = 2	42.6
ACT	384	457	5	2.2
Total			318	96

.. not applicable

Source: Productivity Commission estimates.

Abatement

As stated in section D.3, the state FITs overlap completely with the federal RET scheme. Each MWh of electricity subsidised through state FITs in 2010 led to the creation of RECs that could be used to meet the RET. As such, each MWh of solar electricity simply offsets abatement from other renewable sources. Given that the RET sets a binding target for the use of renewables, the state FITs do not lead to any additional abatement. With the changes to the RET in 2011, this may no longer be the case.

In fact, the nature of the RET in 2010 meant that if the state FITs did induce any additional supply of electricity from solar PV, this would have resulted in a net *increase* in emissions. The reason is that for each MWh of electricity generated through solar PV, owners of systems were granted 5 RECs, so each 'solar-generated REC' was equivalent to only 0.2 MWh of renewable electricity. In general, other renewable generators received only one REC per MWh. Hence, each 'solar-generated REC' that was surrendered in 2010 would have reduced the net generation from renewables by 0.8 MWh, leading to higher aggregate greenhouse gas emissions than if the solar system had not been installed.

Implicit abatement subsidy for solar

As noted, the fact that generation eligible for state FITs in 2010 was also eligible for the RET means that the state FITs did not induce any additional abatement in 2010. However, the FITs did increase the costs to the community of using solar power (because high-cost solar PV displaced lower-cost renewables in the RET target). Therefore, the subsidy equivalent for the FITs (A$96 million) can be added to the estimated subsidy equivalent for the small-scale component of the RET (A$52 million–A$98 million) to estimate the subsidy equivalent to solar PV in 2010. This figure can then be divided by the abatement credited to the small-scale component of the REC (0.2–0.3 Mt CO_2) to estimate the implicit abatement subsidy for abatement through solar PV in 2010. This figure comes in at A$432–A$1043/t CO_2, making the combined effects of the state FITs and small-scale component of the RET one of the highest-cost abatement options identified in this study.

D.6 NSW and ACT Greenhouse Gas Reduction Scheme

GGAS was introduced in NSW in 2003 and the ACT in 2005. GGAS is currently administered by the Independent Pricing and Regulatory Tribunal (IPART) (in the ACT the compliance regulator function for GGAS is performed by the Independent Competition and Regulatory Commission (ICRC)). The ACT GGAS mirrors NSW GGAS. Participants in both schemes are able to surrender certificates created under either the NSW or ACT GGAS. Therefore, the Commission has estimated the subsidy equivalent, abatement and implicit abatement subsidy of the NSW and ACT GGAS as one scheme.

The GGAS scheme was intended to reduce the annual carbon dioxide emissions of the electricity sector in NSW to a benchmark of 7.27 t CO_2 per person in 2009. This is implemented through a 'baseline and credit' system, whereby electricity retailers and some other organisations are legally required to surrender offset certificates if the CO_2 emissions associated with the electricity they supply exceed their benchmark. The firm-level emissions benchmark is determined by market share. Around 23 million certificates were surrendered in 2009. In addition, a relatively small number of certificates were voluntarily surrendered by around 115 organisations and individuals.

Electricity retailers are able to surrender either RECs or NGACs to meet their benchmark. In 2009, around 2.5 million RECs were accepted under GGAS — compared to 23 million NGACs. RECs surrendered under GGAS are also counted under the RET scheme. To avoid double counting of abatement from these

RECs, the Commission has only considered RECs in the analysis of the RET scheme (section D.4). The ability to surrender RECs under GGAS was not expected to have influenced REC prices in 2010. This is because the REC price reflects the additional cost of the marginal renewable electricity generator required to meet the renewable energy target under the RET. Because the GGAS does not induce any additional renewables, it should have no effect on the price of RECs. For this reason, the Commission has not considered the interaction between the GGAS and RET schemes in the estimates of the subsidy equivalent.

NGACs are intended to represent a one tonne reduction in CO_2 emissions and can be established based on the following rules:

- the generation rule
- the demand-side abatement rule
- the carbon sequestration rule
- the large user abatement rule (which allows large electricity customers to claim certificates for reducing on-site emissions from non electricity-related industrial processes at sites they own and control).

As the Commission's analysis focuses on generation of electricity, only NGACs created under the generation rule have been examined. Under the generation rule, generators receive NGACs for either producing electricity that has lower emissions intensity than the NSW average, or reducing the emissions associated with generation that has higher emissions intensity than the NSW average. Credit is given for improvements in 'current greenhouse performance' relative to the baseline, which is defined in terms of prior practice, business as usual, or current industry practice.

Around 15.5 million NGACs were attributed to generators in 2009. This corresponds to around 84 per cent of all NGACs created in 2009. Of generation related NGACs, natural gas and waste coal mine gas projects accounted for around 4 million each, and landfill gas and coal projects accounted for around 3 million each.

The Commission was not able to obtain data on the number of NGACs created in 2010 and has instead used data for 2009. All relevant estimates are reported in 2010 dollars. There have been a number of changes to GGAS since 2009 that may affect the Commission's estimates. These changes were implemented in preparation for the introduction of the proposed Carbon Pollution Reduction Scheme at the time. Relevant changes include:

- new applications for GGAS accreditation were closed on 31 December 2009

- the creation of certificates from some types of generation projects was stopped on 30 June 2010
- the eligibility of energy efficiency demand-side abatement projects was removed on 30 June 2009 (IPART 2011b).

The changes all have the effect of reducing the supply of NGACs in 2009 and 2010, resulting in higher NGAC prices than would otherwise have been the case.

Estimating the subsidy equivalent

The subsidy equivalent for GGAS was estimated by multiplying the number of NGACs issued in 2009 by the average spot market price of NGACs in 2009, expressed in 2010 dollars.

In 2009, the spot market price of NGACs was A$4.34 (A$4.57 in 2010 dollars) (IPART 2011b). The Commission has used the spot market price rather than some composite that takes into account the prices associated with long-term NGAC contracts, because the spot market price better reflects the economic value of the NGACs in 2009 and the financial incentives to participants to create NGACs.

15.5 million NGACs were created in 2009. However, this number included some abatement that is not additional to that which would have occurred in the absence of GGAS. According to the Department of Climate Change:

> GGAS includes non-additional abatement because it applies simple rules (baselines) to assess abatement, and imposes no additional test to discern whether that abatement would have occurred in any event. Examples of the sorts of non-additional activity that could be rewarded under GGAS include:
>
> - output from new gas-fired generators in the National Electricity Market, regardless of whether that new gas-fired generator would have been built and operated even without the support of GGAS; and
> - improvements in efficiency of coal-fired generators, even if those efficiency improvements are economic in their own right. (DCC 2010, pp. 1–2)

Estimates reported in DCCEE (2011c) imply GGAS is leading to 0.7 Mt of additional abatement annually. The Commission has not independently verified this estimate and hence cannot vouch for its accuracy. As 84 per cent of NGACs in 2009 were created by generators, this implies that 0.6 million of the NGACs created by generators in 2009 were for actions that would not have taken place without the scheme. As these NGACs were largely created for non-renewable electricity sector reductions they are not expected to overlap with the other measures analysed for Australia.

Using this estimate of the number of additional NGACs in 2009, multiplied by the 2009 spot price (A$4.57 in 2010 values), the subsidy equivalent of GGAS was estimated to be A$2.7 million. Note that this excludes the value of NGACs attributable to 'non-additional' abatement. This is appropriate because this portion is simply a transfer, and in estimating the subsidy equivalent the Commission is attempting to measure the resource costs associated with actual abatement.

Estimating abatement

Each NGAC is intended to represent a reduction in emissions of one tonne of CO_2. Therefore, abatement was simply equal to the number of additional NGACs, 0.6 million (0.6 Mt CO_2).

Implicit abatement subsidy

The implicit abatement subsidy for GGAS in 2009 was estimated by dividing the subsidy equivalent by abatement. Based on the above estimates, the implicit abatement subsidy was estimated to be A$4.57/t CO_2 — the NGAC spot price in 2009 (converted to 2010 values).

D.7 Queensland Gas Scheme

The Queensland Gas Scheme commenced in 2005, with a requirement on electricity retailers to surrender Gas Electricity Certificates (GECs) in proportion to the amount of electricity they sell. This is intended to ensure that a minimum percentage of Queensland's electricity is sourced from eligible gas generation, including natural gas, coal seam gas, liquefied petroleum gas and some waste gases (DME 2011). Generators that produce eligible gas electricity can apply to become accredited under the scheme, after which time, each MWh of electricity sent out above 2000 levels is eligible for one GEC. A GEC cannot be created from electricity that has been used to create a certificate under another state or Commonwealth greenhouse gas abatement scheme. The mandatory target was 13 per cent in 2009 and 15 per cent in 2010.

The Commission was unable to access Queensland Gas Scheme data for 2010. As a result, the analysis was undertaken for 2009 with values converted to 2010 values using GDP deflators for Australia. There were some differences between 2009 and 2010 that may affect the Commission's estimates for 2009. As discussed above, the mandatory target was increased to 15 per cent in 2010. Despite the increase in the mandatory target, the price of GECs was approximately A$4 lower in 2010. As a

result, using 2009 data as a proxy for 2010 may result in an underestimation of the subsidy equivalent and abatement from the scheme in 2010 — as the target was lower in 2009. However, as the GEC price was lower in 2010, it may also represent an overestimate.

Estimating the subsidy equivalent

The Queensland Gas Scheme is conceptually similar to a renewable energy target, in that a minimum quota is established for a particular type of electricity — in this case, gas. The subsidy equivalent for the Queensland Gas Scheme in 2009 was given by the number of GECs created multiplied by the price of GECs.

In 2009, 5.6 million GECs were created (Queensland Government 2011) and the price of GECs was A$6.49 (DME 2010) (A$6.83 in 2010 values). Based on these figures, the subsidy equivalent was estimated to be A$38.3 million (in 2010 dollars).

Estimating abatement

Abatement from the Queensland Gas Scheme was estimated by multiplying the number of GECs (equivalent to 1 MWh of gas generation) created in 2009 by the difference in the emissions intensity of gas and the source of electricity that is assumed to be displaced by gas under the scheme.

In Queensland, each MWh of additional gas was assumed to displace 1 MWh of black coal. Based on table D.3, the average emissions intensity of gas was assumed to be 0.54 t CO_2/MWh and the average emissions intensity of black coal was assumed to be 0.92 t CO_2/MWh. Thus, each MWh of additional gas reduces emissions by 0.38 t CO_2. Multiplying this by the number of GECs created in 2009 provides an estimate of abatement of 2.1 Mt CO_2.

There are two reasons why this should be considered an upper-bound estimate of abatement from the Queensland Gas Scheme:

- First, the capacity of accredited power stations in Queensland increased from around 1500 MW in 2005 (the start of the scheme) to around 2700 MW in 2009 (DME 2010). It is likely that some of the rapid growth in gas generation was attributable to market factors and effects of public policy decisions that were unrelated to the Queensland Gas Scheme. This is supported by evidence from other NEM states, such as New South Wales and Victoria, which also experienced growth in gas-fired capacity over that period. In New South Wales,

gas capacity increased by around 1100 MW, while in Victoria gas capacity increased by around 300 MW (ABARES 2011).

- Second, the discovery of substantial coal seam gas reserves in Queensland is likely to have contributed to growth in Queensland gas generation (even in the absence of the Queensland Gas Scheme). According to Daley and Edis (2011), there was a ten fold increase in the state's known coal seam gas reserves in the five years following the introduction of the scheme. It is not known to what extent these discoveries were motivated by the higher gas electricity prices resulting from the Queensland Gas Scheme.

Implicit abatement subsidy

The implicit abatement subsidy for the Queensland Gas Scheme in 2009 was estimated by dividing the subsidy equivalent by abatement. Based on the above estimates, the implicit abatement subsidy was estimated to be A$18/t CO_2.

D.8 Summary

This section summarises the above results and combines the estimates of subsidy equivalent and abatement for all the policies to generate estimates for the Australian electricity sector.

Total subsidy equivalent

The total subsidy equivalent is simply equal to the sum of the subsidy equivalents for each of the policies analysed (table D.9). In 2010, the total subsidy equivalent for Australia was estimated to be between A$473 million and A$694 million. This represented between 0.4 and 0.5 per cent of Australia's GDP.

Total abatement

As noted in section D.3, overlaps between policies have been accounted for in the estimates for individual policies. Thus the abatement estimates can be added together to provide an estimate of total abatement for Australia's electricity sector (no abatement has been attributed to the FITs because they overlap fully with the RET). In 2010, total abatement for the Australian electricity sector was estimated to be between 7–11 Mt CO_2 (table D.10).

In 2010, Australia's electricity sector emitted 196 Mt CO_2. Therefore, the abatement estimate represents between 3.6 per cent and 5.5 per cent of Australia's 2010 electricity sector emissions.

Table D.9 **Total subsidy equivalent**
Australia, 2010

	Total subsidy equivalent		
Policy	*'Central'*	*High*	*Low*
	A$m (2010)	A$m (2010)	A$m (2010)
Renewable Energy Target	356	556	335
Feed-in tariffs	96	96	96
Queensland Gas Scheme	38	38	38
Greenhouse Gas Reduction Scheme	3	3	3
Total	494	694	473

Source: Productivity Commission estimates.

Table D.10 **Total abatement**
Australia, 2010

Policy	*'Central'*	*High*	*Low*
	Mt CO_2	Mt CO_2	Mt CO_2
Renewable Energy Target	7	8	4
Greenhouse Gas Reduction Scheme	0.6	0.6	0.6
Queensland Gas Scheme	2[a]	2[a]	2[a]
Total	10	11	7

[a] The estimates of abatement under the Queensland Gas scheme should be interpreted as an upper bound.

Source: Productivity Commission estimates.

Average implicit abatement subsidy

Based on the estimates above, the average implicit abatement subsidy for the Australian electricity sector was estimated to be between A$44 and A$99/t CO_2 (table D.11).

Table D.11 **Average implicit abatement subsidy**
Australia, 2010

	Implicit abatement subsidy		
Total subsidy equivalent scenario	*High abatement*	*'Central' abatement*	*Low abatement*
	A$/t CO_2	A$/t CO_2	A$/t CO_2
High	65	69	99
'Central'	46	49	70
Low	44	47	67

Source: Productivity Commission estimates.

D.9 Other Australian electricity generation policies and programs

The Commission has only estimated the subsidy equivalent and abatement for a subset of emissions-reduction policies in Australia. In particular, this appendix has focused on policies that applied to the electricity generation sector in 2010, and were considered likely to be leading to material levels of abatement, or imposing material resource costs in that year.

The Commission did not analyse the effects of research and development or technology demonstration policies, because the link between current spending and abatement is tenuous. Nor were the effects of energy efficiency policies analysed in this appendix, because these policies relate to electricity consumption, rather than generation. These policies are analysed in greater depth in appendix C. Finally, the appendix does not address the effects of land use, planning or transport policies, although some of these policies could have a material effect on future emissions trends.

The Commission's analysis for the Australian electricity generation sector includes only those policies that passed a materiality threshold. While the four measures are only a fraction of those in place, they are considered to represent a large proportion of the total subsidy equivalent (and associated abatement) applicable in the electricity generation sector.

Excluded electricity generation policies

One policy — the Northern Territory Solar Cities program — was not included in the analysis due to data constraints. This program includes a feed-in tariff of 46 cents/kWh for small-scale solar PV supplying electricity to the

Northern Territory grid. However, as the abatement from feed-in tariffs overlaps with that of the RET, the Solar Cities program was assumed to have not contributed any additional abatement. Moreover, due to the small population of the Northern Territory, relative to other states and territories, the subsidy equivalent from this program was expected to be small. Therefore, it would probably not have a material effect on the Commission's estimates of the total subsidy equivalent.

The Commission identified a number of electricity sector measures that were not included in the analysis as they did not meet the Commission's materiality criteria for policy inclusion. These include:

- Queensland Renewable Energy Fund — A$50 million funding program to support the development and deployment of renewable electricity generation in Queensland
- Northern Territory 'Make the Switch' capital grants program — capital grants to tourism operators replacing fossil-fuel generators with renewable electricity
- Solar Schools programs (Commonwealth, South Australia and Western Australia Governments) — grants to eligible schools to install solar PV systems
- various other government grants for the development of renewable electricity. Examples include: the Commonwealth Government's A$1.5 billion Solar Flagship program (although this policy could have material effects in future years, in 2010 the effects were limited to the short listing of a number of solar PV projects, and the provision of funds to undertake feasibility studies); the Kogan Creek Solar Boost Project; the Victorian Large Scale Solar Project; and the Low Emissions Energy Development Fund.

The exclusion of these policies does not imply that they are not capable of reducing emissions. Rather, they were excluded because in 2010, the resource costs of the policies were probably small. In particular, each of these excluded policies relate to capital subsidies or grants. On an annualised basis, they probably did not provide a substantial subsidy equivalent relative to the other measures analysed in 2010.

A second consideration is that many of these policies subsidise renewables. While Australia has a binding RET, it was likely that these policies will not deliver additional abatement (because abatement through renewables was a function of the binding target).

Committed policies

The Commission did not identify any 'committed' policies, as defined in chapter 3, that are likely to have a material effect on future estimates of implicit abatement subsidies. However, the Australian Government has announced its intention to

introduce an emissions trading scheme from 1 July 2012. The emissions trading scheme permit price is expected to be fixed for a period of three to five years before transitioning to a full emissions trading scheme. Such a policy could have a considerable effect on emissions and the subsidy to lower-emissions generation in Australia.

E China's electricity generation sector

E.1 Introduction

The Commission estimated the subsidy equivalents and abatement attributable to six policies applying in China's electricity generation sector. Five of these policies provide incentives in the form of feed-in tariffs or capital subsidies for the use of renewable energy sources (wind, solar photovoltaic and biomass). The sixth policy, the 'Large Substitute for Small' (LSS) program targets improvements in the efficiency of the coal-fired electricity generation fleet.

The Commission had to exclude some policies (detailed in section E.10) from its analysis. Some policies were excluded because preliminary analysis suggested that they were not likely to be material, relative to the other policies analysed, or because their main effect was not related to electricity generation. Some other policies were excluded because of a lack of data. These policies may have had material effects, but the Commission considers that the policies that have been analysed capture a large proportion of the types of measures being pursued in China's electricity generation sector, the subsidies they provide to low-emissions generation and the abatement that is being achieved.

References in this appendix to Vivid Economics refer to unpublished data supplied to the Productivity Commission by that contractor.

Year of analysis

The Commission's preference was to estimate the subsidy equivalents and abatement attributable to policies in 2010. However, in some cases, the data were not available and data from previous years had to be used. The results presented were derived using the following approaches (in order of preference).

- Where data on the subsidy and eligible generation were available for 2010, they were used as the basis for the analysis.
- In some cases, the Commission was able to access data on the subsidy offered in 2010, but could only access data on how much of a particular type of generation

(for example wind, solar or biomass) was supported by subsidies in 2009. In these cases, the Commission has used 2009 generation by the subsidised generator as a proxy for 2010 generation. This assumption was relaxed in the sensitivity analysis.

- Where the Commission was only able to access data for 2009, the results were estimated for 2009 and converted to 2010 dollars.

Currency conversion factors

The Commission has reported all estimates in 2010 Australian dollars. Exchange rates and GDP deflators are reported in table E.1.

Table E.1 **Exchange rates and deflators**
China 2009, 2010

Value	*Year*	*Value*
Market annual average exchange rate	2010	A$0.161/CNY
GDP deflator index — China (2000 = 100)	2009	266
	2010	282

Source: RBA (2011); IMF (2011).

Counterfactual electricity prices

In order to estimate the subsidy equivalent for some policies it was necessary to make an assumption about the price that the generator of subsidised electricity would receive in the absence of the policy. For China, this is a conceptually difficult exercise. Electricity prices for all generators in China are set by the Chinese Government. Because the prices that Chinese generators receive are not set in a market, it is not realistic to assume that there is a counterfactual price that generators would be receiving in the absence of government policies.

In order to apply the Commission's approach, it was necessary to choose a proxy for the counterfactual electricity price that subsidised renewable generators would have received in the absence of particular policies. The Commission elected to use an unweighted national average of the regional 'benchmark on-grid electricity tariffs' received by thermal electricity generators in November 2009. The average value of the tariff was CNY 0.381/kWh (Ma 2011).

The benchmark on-grid tariffs are paid to approximately 80 per cent of total Chinese electricity that is produced using thermal generation (of which coal accounts for the vast majority). As such, the differences between the benchmark

tariffs and the prices received by subsidised generators give an indication of the premium being paid for renewable electricity over conventional electricity.

It is possible that these tariffs represent an overestimate of the average wholesale price received by electricity generators. China has significant hydroelectric capacity (approximately 210 GW in 2010), and on-grid tariffs for hydropower tend to be lower than those for coal-fired electricity. For example, Ma (2011) stated that 'average on-grid tariffs of hydroelectric plants were CNY 0.27/kWh in 2008' (Ma 2011, p. 2641). In the same year, average tariffs for coal-fired plants were around CNY 0.37/kWh. Using the benchmark on-grid tariff for coal could therefore understate the value of some production subsidy equivalents.

Counterfactual emissions

To estimate the abatement attributable to policies that encourage the use of renewable energy, the Commission has used a counterfactual emissions intensity that is based on the 'operating margin' reported by the Chinese Government for the purposes of Clean Development Mechanism projects (Michaelowa 2011). Under the Clean Development Mechanism, countries that claim Certified Emissions Reduction certificates must provide data on grid emissions factors. These were used to estimate the reduction in emissions arising from renewable electricity generation. Under the Clean Development Mechanism, the operating margin reflects the reduction in emissions from the marginal generator. The Chinese Government has published operating margins for six Chinese electricity grids. The national average operating margin is 1.003 t CO_2/MWh of electricity displaced by renewables.

Michaelowa (2011) assessed the assumptions used to derive the operating margin, and found that the approach was not entirely consistent with the rules of the Clean Development Mechanism. The aggregate effect was likely to be to overstate the operating margin. For example, the operating margin calculations did not take into account the increased use of supercritical coal plants (which have a lower emissions intensity) (Michaelowa 2011). To account for this, the Commission conducted sensitivity analysis using a lower emissions counterfactual.

The rate chosen for the sensitivity analysis is the Chinese coal-fired plant 'build margin' specified by Michaelowa (2011). This is an estimate of the emissions intensity of the most recently-built 20 per cent of coal-fired plants built in China. This value appears to take into account the increasing efficiency of the Chinese coal-fired generation fleet, and is approximately 20 per cent lower than the 'operating margin' (0.8042 t CO_2/MWh).

The Commission has used a different approach to estimate the relevant emissions intensities for the LSS program. This approach is discussed in section E.3.

E.2 Overview of electricity generation in China

Structure of the Chinese electricity sector

There is a high degree of government ownership in the Chinese electricity generation sector. Plants are often classified as either:

- state-owned plants — directly under government control
- 'independent plants' — owned by provincial governments and private investors (Ma 2011).

State-owned plants and 'independent plants' each account for around half of China's electricity generation (EIA (US) 2011f). According to the International Energy Agency (IEA 2007), the various forms of ownership are not always clear. The Energy Research Institute (ERI) (China) (pers. comm., 25 April 2011) stated that in reality most Chinese power plants are state-owned.

Generation was separated from other parts of the electricity sector in 2002 (IEA 2007). The electricity network is divided into seven grids with limited interconnectivity, and is operated by two government monopolies. The State Grid Corporation of China operates the electricity network in northern and central China, while the China Southern Power Grid operates the electricity network in southern China.

Electricity prices

In general, central and provincial governments determine how much electricity generators are allowed to sell and what prices they receive. Electricity prices vary among provinces and are determined by the National Development and Reform Commission based, in part, on estimates of generation costs and recommendations from local pricing bureaus (IEA 2010n). Adjustments to electricity prices received by coal-fired generators are allowed when the price of coal moves by more than 5 per cent within a period of six months. However, since 2004 electricity prices have been adjusted only three times despite the 5 per cent threshold being exceeded 10 times (Howes and Dobes 2010; Ma 2011).

Dispatch

In principle, Chinese electricity dispatch is organised by providing a similar amount of hours per year to each plant regardless of its efficiency or fuel consumption costs. This means that demand growth risk and the system reserve needs are proportionally shared by all plants. In the event that grid load is reduced due to lower demand, all plants are required to evenly reduce their output (Vivid Economics 2011). However, the IEA (2007, p. 279) noted that 'local control over dispatch often means that in practice preference goes to locally-owned plants, which may be smaller and less efficient, while newer plants that are more efficient and have better pollution control may be left idle'. New dispatch rules were trialled in 2007, with the intention of bringing lower emissions intensity plants on line before higher carbon intensity plants, but it is not clear how far these rules have been extended.

Electricity markets

Between 2000 and 2006, the Chinese government experimented with limited electricity markets in some areas. In 2003, the government introduced a partially competitive wholesale power market in parts of eastern and southern China on a trial basis. Electricity prices were determined through a competitive bidding process. Participating power plants were limited to selling a maximum of 10 to 20 per cent of their electricity through the market. All trials were terminated by 2006, and the Commission is not aware of any subsequent use of wholesale electricity markets in China.

Key statistics

Electricity prices

The average provincial wholesale electricity price for thermal power in China increased from around CNY 0.33/kWh in 2005 to around CNY 0.38/kWh in 2009 (table E.2). Prices varied substantially by province in 2009, with Ningxia in western China having the lowest wholesale electricity price (CNY 0.27/kWh) and Guangdong in southern China having the highest wholesale electricity price (CNY 0.50/kWh). The wholesale prices of hydroelectricity are typically lower than thermal power wholesale prices. In 2008, the average hydroelectricity price was estimated to be 27 per cent lower than the average thermal electricity price (Ma 2011).

Table E.2 **Average provincial wholesale electricity prices for thermal power**

China, 2005–2009

May 2005	*June 2006*	*June 2008*	*August 2008*	*November 2009*
CNY/kWh	CNY/kWh	CNY/kWh	CNY/kWh	CNY/kWh
0.33	0.35	0.36	0.38	0.38

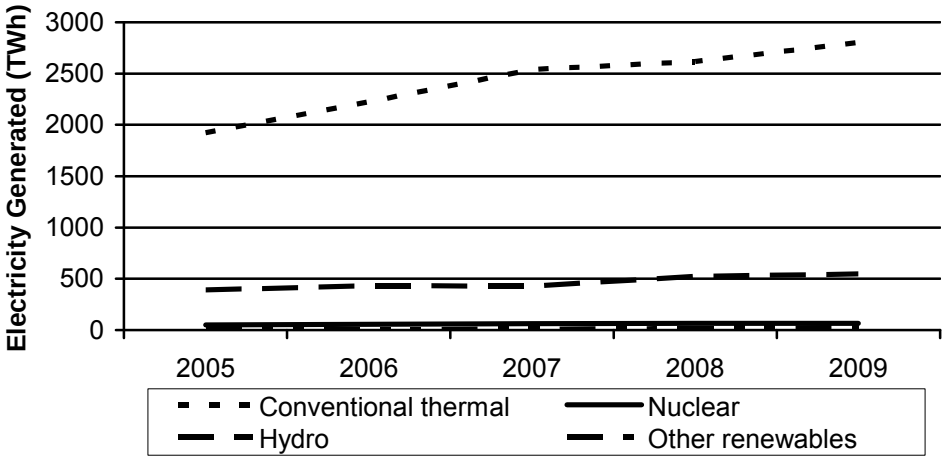
Source: Ma (2011).

Electricity generation

The Chinese electricity sector has expanded rapidly in recent decades. According to national statistics, more than five times as much electricity was generated in 2007 as 1990 (NBS (China) 2009). The Chinese electricity sector has been dominated by coal-fired generation, which accounted for around 80 per cent of national electricity in 2009. Hydro is the most common renewable source, contributing around 16 per cent of electricity generation in 2009 (EIA (US) 2011k). There are also small amounts of nuclear and wind. The share of renewables in total electricity generation was fairly stable between 2005 and 2009 at around 17 per cent (figure E.1).

Figure E.1 **Electricity generated by fuel type**

China, 2005–2009



Source: EIA (US) (2011k).

Emissions

Emissions from the Chinese electricity generation sector increased from around 550 Mt CO_2 in 1990 to around 2100 Mt CO_2 in 2005. Malla (2009) attributes most

of this increase to higher electricity production, while a small shift in the electricity generation mix towards coal also contributed (coal being a relatively emissions-intensive source of electricity generation — table E.3). There was some increase in the average fuel efficiency of power plants over that period, which reduced the emissions intensity of electricity generation and slowed the growth in emissions.

Table E.3 **Emissions intensity of power generation**
China, 2008

Electricity source	*Emissions intensity (t CO_2/MWh)*
Conventional coal	1.186
Gas	0.434
Supercritical coal	0.913
Ultra-supercritical coal	0.715
Integrated gasification combined cycle coal	0.718
Pressurised and fluidised bed combustion coal	0.790
Oil	0.780

Source: Wang and Nakata (2009).

E.3 Large Substitute for Small program

In 2006, the Chinese Government implemented the LSS program. This program aims to decommission small inefficient thermal power plants and replace them with larger, more advanced electricity generators.

During the 11th Five Year Plan (2006–2010) 50 GW of capacity was targeted for closure (NDRC 2009). According to the IEA (2010c) the following categories of thermal power units targeted for closure were:

- conventional thermal power generation units below 50 MW
- conventional thermal power generation units below 100 MW that have been operating for over 20 years
- conventional thermal power generation units below 200 MW that have reached the end of their design lives
- conventional thermal power generation units with coal consumption 10 per cent higher than the provincial average or 15 per cent higher than the national average
- all generation units that fail to meet environmental standards, laws or regulations.

A number of sources suggest that the LSS target was met earlier than expected and that by 2010 the total capacity of plants shut down was considerably higher than the

50 GW target (NDRC 2009; IEA 2010c; Zhang 2010). Data provided by the ERI (China) (pers. comm., 25 April 2011) indicate that by July 2010, a total capacity of 71.4 GW had been shut down under the LSS program (table E.4).

Table E.4 **Capacity of small coal-fired plants shut down under the LSS**

China, January 2006 – June 2010

Year	*Annual capacity*	*Cumulative capacity*
	GW	GW
2006	3.1	3.1
2007	14.4	17.5
2008	16.7	34.2
2009	26.2	60.4
2010 (half year)	11.0	71.4

Source: ERI (China) (pers. comm., 25 April 2011).

The Chinese Government appears to have implemented a number of policies and mechanisms to support the closure targets for the LSS program. These include:

- the Government requiring any electricity company that wants to expand its coal-based generation capacity to shut down some of its small capacity before approval for new plants is given (ADB 2008; IEA 2010c)
- the Energy Conservation Power Generation scheduling rule, which distributes the grid load on the basis of the energy efficiency, emissions levels and water usage of all grid connected operators. This contrasts with the historically used 'even load scheduling rule' that distributed the grid load evenly to all grid-connected generators. It is unclear to what extent the Energy Conservation Power Generation scheduling rule has been applied (ADB 2008; IEA 2010c; Ma 2011)
- differential electricity tariffs. Song, Cosbey and Savage (2009) and Ma (2011) indicated that the government has lowered the generation tariff received by small thermal power plants to make them less profitable and encourage the transfer of production quotas to more efficient generators
- coal technology mandates. As a further incentive to build more efficient plants, the Chinese Government appears to have implemented a policy that promotes the use of start of the art commercially available coal-based technologies, including supercritical and ultra-supercritical generation (ADB 2008; IEA 2010c; WRI 2009). The Commission was unable to verify what incentives or regulatory mandates have been used to support this measure, or whether mandates apply to all sizes of new coal-based generation plants. The Commission has therefore assumed that new plants built to replace those shut

down under the LSS have used a range of advanced technologies. This is discussed further in the sections below.

The Commission's approach to estimating the subsidy equivalent of the LSS program

The LSS effectively forces plant operators to retire inefficient plants early and replace them with larger, more efficient ones. Therefore, the Commission has estimated the subsidy equivalent of the LSS as the cost of bringing forward this investment.

The approach follows from the assumption that these new larger plants would (in the absence of the policy) have been built once existing plants came to the end of their economic life. The subsidy equivalent estimates do not include any capital costs associated with the plants shut down under the LSS, as this cost is assumed to be sunk. Instead, the cost of the policy is considered to be the additional cost of bringing forward an investment that would have happened in time. This implicitly assumes that plants shut down under the LSS would not have been replaced during the LSS time period in the absence of the policy.

The plant owner is assumed to repay the cost of the new plant over the lifetime of the asset. Therefore, when considered in the year of the Commission's analysis, the relevant cost is the annual cost of these repayments. However, because larger, more advanced plants operate more efficiently than smaller plants, there are operating cost savings (relative to the old plants) in terms of lower fuel, maintenance and other operating costs. These savings are subtracted from the annualised capital costs of the new plants to give the Commission's estimates of the net cost of the LSS program (Box E.1). This is the net production subsidy equivalent.

This cost is considered over the time period which the investment was assumed to have been brought forward. For example, assume that the LSS program were to lead to a new larger plant being built to replace a number of smaller plants and that these plants were half way through their 30 year economic life. The annual cost of the LSS program would be considered for the first 15 years of the new plant's economic life, after which time the new plant would have been built, so no further costs would be taken into account when estimating the subsidy equivalent. This effectively attributes half the cost of the new plant to the LSS program.

Box E.1 **Estimating the subsidy equivalent of the LSS program**

The annual capital cost of the LSS program has been estimated as:

$R_i = [P_i * r]/[1-(1+r)^{-n}]$

where:

R_i = the annual cost of the LSS program (analogous to an annual repayment on a loan)

P_i = the principal (total capital cost associated with building a new plant)

r = the discount rate (cost of capital)

n = the economic life of the asset (in years)

R_i can then be converted to a value per unit of output by dividing R_i by the annual output of the plant. The annual output of the new plant (q_i) is calculated as:

$q_i = C_i * 24 \text{ hours} * 365 \text{ days} * cf_i$

Where C_i is equal the total capacity of plant closures under the LSS and *cf* is equal to the capacity factor of the new facility.

The savings in operating costs (per MWh) are then subtracted from the annualised capital costs. The savings in operating costs are (v_o-v_i), where v_i is equal to the total operating (variable) cost of the new plant and v_o is the operating costs of the old plants.

The capital cost per MWh (net production subsidy equivalent $\square_i$) for *i* is therefore:

$\square_i = (R_i/q_i) - (v_o-v_i)$

And the subsidy equivalent of the LSS program is:

$SE_i = \square_i \, q_i$

Similar to capital subsidies, the Commission has estimated the subsidy equivalent for all plants introduced under the scheme, over the timeframe that the policy has been in place (using the total cumulative capacity of plants shut down). This is because it is assumed that costs are still being incurred from investments brought forward previously — if, in the year of the Commission's analysis, it was assumed that the new plant would still not have been built in the absence of the policy (and instead the old plant would have continued operating).

The following sections outline the assumptions and data the Commission has used to estimate the subsidy equivalent of the LSS and provides the Commission's estimates based on a range of variations to these assumptions.

Capital costs of new plants

Since the implementation of the LSS program in 2006 until July 2010, around 71 GW of small and inefficient plants have been shut down (table E.4). The cost of

replacing these plants is dependent on the type of technology used. A large number of new plants have been built over the period of the Commission's analysis, using various coal-based generation technologies, including conventional coal (subcritical), supercritical and ultra-supercritical. As discussed earlier, some of the growth in supercritical and ultra-supercritical plants appears to have been induced by the Chinese Government's encouragement of the use of such technologies. As a result, the Commission was unable to determine with certainty which types of plants have been built in response to the LSS, compared to those that have been built to meet increased demand for electricity ('new growth') and in response to other advanced coal technology policies.

The Commission therefore assumed that the mix of new plants built to replace those shut down under the LSS mirrors the mix of new coal-based plants built across China over the period 2006 to 2010. This mix is based on IEA (2011a) data on the proportion of each technology type used for new plants built in China since 2006 (table E.5).

Table E.5 **Capacity and technology type of new coal-based plants[a]**
China, January 2006 – June 2010

Technology type	*Capacity of new plant*	*Percent of total*	*Estimated capacity replacing old plants shut down under the LSS[b]*
	GW	%	GW
Subcritical	196	34.4	24.6
Supercritical	257	45.2	32.2
Ultra-supercritical (<1000 MW)	39	6.9	4.9
Ultra-supercritical (1000 MW or above)	77	13.5	9.7
Total	**569**	**100**	**71.4**

a The Commission used data from the IEA Coal Power database (IEA 2011a) to estimate the proportion of new plants built using each technology. Where the technology type was not specified, the plant has been allocated to a technology type based on plant size. All plants under 600 MW were assumed to be subcritical. Plants between 600 MW and 1000 MW were assumed to be supercritical and plants of 1000 MW or above were assumed to be ultra-supercritical. **b** This column applies the proportion of each technology type to the total capacity of plants shut down under the LSS (71.4 GW).

Sources: IEA (2011a); Productivity Commission estimates.

To estimate the total capital cost of these new plants (P_i) the Commission has used an average capital cost for each technology type. There is a range of estimates available on the capital costs of coal-based plants in China (table E.6).

Table E.6 **Capital costs for new coal-based plants** [a, b]
China, 2010

Technology type	*IEA (2007)*	*IEA (2009)*	*IEA (2010c)*	*ERI (2011)*[c]	*Average*
	CNY/kW	CNY/kW	CNY/kW	CNY/kW	CNY/kW
Subcritical	4 313–5 176	3 493–4 657	3 824	3 350–3 500	4 063
Supercritical	5 176–7 764	3 704–4 657	3 978	3 500–3 700	4 538
Ultra-supercritical	5 176–7 764	4 022–5 504	3 964	3 700–4 000	4 851

a Capital costs include all plant sizes for each technology type. All capital costs have been converted to 2010 costs using GDP deflators from the International Monetary Fund (IMF 2011). Where unclear or not specified, the Commission has assumed that the capital cost provided in the original source was in nominal values of the year of the publication. For IEA (2007) data, capital costs have been converted from US$ to CNY using an average market exchange rate of CNY 7.61 per US$ **b** For IEA (2009) data, capital costs vary depending on whether the plant is fitted with either or both of, fluid gas desulphurisation or selective catalytic reduction. **c** Capital costs are for 2010 and do not include fluid gas desulphurisation or selective catalytic reduction.

Sources: IEA (2007, 2009, 2010c); ERI (China) (pers. comm., 25 April 2011).

Based on these data, the Commission has assumed an average capital cost of CNY 4063/kW for subcritical plant, CNY 4538/kW for supercritical plant and CNY 4851/kW for all sized ultra-supercritical plant. These costs have been applied to the Commission's estimates of the capacity of new plants built to replace plants shut down under the LSS program (table E.5). This results in an estimate of the total capital cost for plants built under the LSS of CNY 317 billion (A$51 billion).

Implicit in this estimate is the assumption that the capital costs for building new coal-based plants have been relatively constant over the period of analysis (2006–2010). However, the Commission has used an average capital cost for each technology type based on capital cost data for 2007, 2009 and 2010. This range of estimates is likely to account for some of the changes in capital costs over the period.

Annualised capital costs

Using the above estimate of the total capital cost of replacing plants shut down under the LSS, the Commission estimated the annual cost of the LSS in 2010 by annualising the total capital cost over an assumed economic life of new coal-based plants. The replacement cost is annualised using the formula for R_i described in box E.1.

Assuming an economic life of 35 years and a real discount rate of 7 per cent, the annualised capital cost in 2010 was estimated to be CNY 24 billion (A$3.9 billion).

To express these figures on a per unit of generation basis, the Commission has estimated annual generation from the new plants. The Commission assumed that the capacity factor was 57.4 per cent, based on advice from the ERI (China)

(pers. comm., 25 April 2011).[1] Applying this to new capacity of 71 GW gives an estimate of annual generation of 359 TWh (equal to 71 GW x 24 hours x 365 days x 57.4 per cent capacity factor). Dividing the annual repayment cost by this figure gives an annualised cost of CNY 68/MWh (A$11/MWh).

Operating cost savings and the production subsidy equivalent

In order to estimate the production subsidy equivalent ($\square_i$), it is necessary to account for savings in operating costs from larger more efficient plants.

The Commission has estimated the savings in operating costs using data on the heat rate of different sized plants. This provides an estimate of the savings in fuel costs. While there are likely to be operating savings in the form of reduced maintenance, labour and other operating costs, the Commission was unable to obtain data on these. Therefore these were not considered in the analysis. This exclusion is not considered to be a significant issue, as fuel costs represent the majority of variable costs for coal-based plants, in the order of 50–75 per cent. Nonetheless, it will mean that the estimates will understate the savings in operating costs. While there may also be other costs associated with the scheme, such as compensation paid to operators of plants or to employees, the Commission has not considered these costs in the analysis. This is because such costs are simply a transfer rather than a resource cost.

Table E.7 outlines the heat rates (grams of coal used per kWh) of various sized coal plants sourced from the Asian Development Bank (ADB 2008). The Commission was unable to obtain data on the average size of plants shut down under the LSS. However, based on the categories targeted for closure under the program, the Commission has assumed that on average, plants of size 50 MW were shut down. These plants have a heat rate of 440 g/kWh (table E.7).

The IEA (2010l) estimated that the average cost of coal in China is CNY 600/t. This implies that the average fuel costs of the 50 MW plants shut down under the LSS are CNY 0.264/kWh.

Further, the Commission estimated the weighted average heat rate of new plants using the average profile of new built plants in China over the LSS period (from table E.5) to be 311 g/kWh. This implies that the average fuel cost of new plants is CNY 0.19/kWh.

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1 The ERI (pers. comm., 25 April) provided the Commission with data on the capacity factor of thermal power generation from 2005 to 2010. These capacity factors were, 67 per cent (2005), 64.1 per cent (2006), 60.7 per cent (2007), 56.1 per cent (2008), 55.5 per cent (2009) and 57.4 per cent (2010).

Table E.7 **Efficiency and emissions intensity of coal-based plants**
China, 2008

Plant type	*Plant size (MW)*	*Heat rate*[a]
	MW	g/kWh
Ultra-supercritical	1 000	286
Ultra-supercritical	600	292
Supercritical	600	299
Subcritical	300	340
Subcritical	100	410
Subcritical	50	440
Subcritical	25	500
Subcritical	12	550
Subcritical	6	600+

[a] The heat rate is the amount of coal (in grams) required to generate a kWh of electricity.

Source: ADB (2008).

Therefore, for each MWh of electricity that would have been generated from the old plants, the fuel cost savings were estimated to be CNY 78/MWh (A$13/MWh). Subtracting this from the estimate of the per unit capital cost figure (CNY 68/MWh, A$11) gives a production subsidy equivalent of CNY -10/MWh (A$-2). This suggests that the savings in operating costs from the new plants outweigh the annualised replacement cost of these plants. In other words, the policy could be justified on productive efficiency grounds alone.

Estimating the subsidy equivalent

The subsidy equivalent of the LSS program was estimated by multiplying the production subsidy equivalent (estimated above) by the annual level of generation.

Table E.8 outlines the assumptions and calculations used to estimate the subsidy equivalent for the LSS. This analysis suggests that the subsidy equivalent is in the order of CNY -3.5 billion (A$-567 million). The negative subsidy equivalent represents a net monetary benefit from the scheme.

Table E.8 **Summary of assumptions and calculations used to estimate the subsidy equivalent of the LSS**
China, 2010

Variable	*Units*	*'Central'*
Annualised capital cost[a]	CNY b	24.5
Generation per year	TWh	359
Annual repayment per unit of generation	CNY/MWh	68.2
Operating cost savings	CNY/MWh	78
Production subsidy equivalent	CNY/MWh	-9.8
Subsidy equivalent	**CNY b**	**-3.5**
Subsidy equivalent	**A$m**	**-567**

[a] Based on a total replacement cost of CNY 317 billion and a 7 per cent discount rate.

Source: Productivity Commission estimates.

Estimating abatement

The abatement attributable to the LSS program was determined by the difference in the emissions intensity of the old plants shut down under the LSS and the emissions intensity of the new plants, multiplied by the annual generation of the new plants. The annual generation of the new plants is equivalent to the estimated generation of the old plants (because only the costs attributable to replacing the old plants are counted for the purposes of the analysis).

Abatement (in tonnes of CO_2) attributable to the LSS is therefore:

$$A_i = q_i(a_c - a_i)$$

where a_c is the emissions intensity of the plants subject to closure, a_i is the emissions intensity of new plans, and q_i is the total annual generation (in MWh) of new plant (that is replacing old plant).

Estimating the average emissions intensity of generators

In order to estimate the emissions intensity of the replaced electricity generation, the Commission has used the data on the thermal efficiency of various sized coal plants in China combined with the following approach.

- Michaelowa (2011) suggests that a coal plant with a thermal efficiency of 39 per cent has an emissions intensity of 0.804 t CO_2/MWh. (The thermal efficiency relates to the amount of coal required to generate a unit of electricity).
- Based on this relationship between thermal efficiency and emissions intensity the Commission has used a 'scaling factor' of 0.314 t CO_2/MWh (0.804 x 39%).

- The Commission divided this 'scaling factor' by the thermal efficiencies of each plant size to estimate the emissions intensities for each plant size (table E.9).

Based on this approach, a 50 MW coal plant is estimated to have an emissions intensity of 1.12 t CO_2/MWh. This estimate is consistent with other estimates of the emissions intensity of small thermal power plants in developing countries. For example, Ghosh (2010) stated that region-wide emissions intensities for state-owned thermal power units in India were in the range 0.79 – 1.39 t CO_2/MWh in 2008, with an average emissions intensity for these units of 1.08 t CO_2/MWh. It is unclear what sized plant this estimate is based on. However, according to Ghosh (2010, p. 6890), 'the relatively poor performance of the State units is principally because of their age (vintage) and smaller ratings'.

For the emissions intensity of the new plants, the Commission has used the average type and size of coal plants built in China in 2006–2010 (table E.5) and the Commission's estimates of emissions intensities (table E.9), to obtain a weighted average emissions intensity of new plants of 0.795 t CO_2/MWh.

Therefore, for each MWh of generation shut down, the abatement is estimated at 0.33 t CO_2 (assuming old 50 MW plants were shut down). This gives an estimate of abatement of 119 Mt CO_2.

Table E.9 **Efficiency and emissions intensity of coal-based plants**
China, 2008

Plant type	*Plant size*	*Thermal efficiency*	*Estimated emissions intensity*[a]
	MW	%	t CO_2/MWh
Ultra-supercritical	1 000	43.03	0.73
Ultra-supercritical	600	42.09	0.75
Supercritical	600	41.10	0.76
Subcritical	300	36.15	0.87
Subcritical	100	29.98	1.05
Subcritical	50	27.93	1.12
Subcritical	25	24.58	1.28
Subcritical	12	22.35	1.41
Subcritical	6	20.48	1.53

[a] The emissions intensities are estimated based on the thermal efficiency of the plant, and the thermal efficiency (39 per cent) and emissions intensity (0.804 t CO_2/MWh) of the average new build plant according to Michaelowa (2010), which implies a 'scaling factor' of 0.314 t CO_2/MWh.

Sources: ADB (2008); Productivity Commission estimates.

The implicit abatement subsidy

The implicit abatement subsidy of the LSS is estimated by dividing the subsidy equivalent by abatement. Using the Commission's central estimate of the subsidy equivalent of CNY -3.5 billion, and abatement of 119 Mt CO_2 from above, gives an estimate of the implicit abatement subsidy of CNY -30/t CO_2 (A$-5) (table E.10).

Table E.10 **Implicit abatement subsidy of the LSS**
China, 2010

Variable	*Units*	*'Central' estimate*
Subsidy equivalent[a]	CNY b	-3.5
Subsidy equivalent	A$m	-567
Abatement[b]	Mt CO_2	119
Implicit abatement subsidy	**CNY/t CO_2**	**-29.7**
Implicit abatement subsidy	**A$/t CO_2**	**-4.8**

[a] The subsidy equivalent is based on an operating cost saving of CNY 78/MWh and an interest rate of 7 per cent. [b] Abatement is based on an emissions intensity of 1.125 t CO_2/MWh for the old plants and an emissions intensity of 0.795 t CO_2/MWh for new plants.

Source: Productivity Commission estimates.

Sensitivity analysis

The Commission's estimate of the capital cost, abatement and implicit abatement subsidy are sensitive to a number of assumptions. In particular, the interest rate used to annualise the capital cost of plants, operating cost savings and the emissions intensity of the old and new plants. This section sets out sensitivity analysis around these assumptions.

Subsidy equivalent

Varying the discount rate has a significant effect on the estimate of the subsidy equivalent:

- With a 3 per cent discount rate, annual capital costs are estimated to be CNY 14.7 billion (A$2.4 billion), and CNY 41/MWh (A$6.60/MWh) on a per unit of generation basis.
- With an 11 per cent discount rate, annual capital costs are estimated to be CNY 36 billion (A$5.8 billion), and CNY 100/MWh (A$16/MWh) on a per unit of generation basis.

If no other parameters are varied, this implies that the subsidy equivalent is:

- CNY -13.3 billion (A$-2.1 billion) using a 3 per cent discount rate
- CNY 7.8 billion (A$1.3 billion) using an 11 per cent discount rate.

This is a significant result as it shows that under certain parameters (specifically, a high cost of capital) the subsidy equivalent is positive.

Varying the assumptions about the operating cost savings has an effect, albeit less pronounced than the discount rate. If it is assumed that the average size of plants shut down under the LSS is 25 MW (rather than 50 MW as assumed above) then the savings in fuel costs from replacing the small plants with larger, more efficient ones will be larger (CNY 114/MWh) (A$18/MWh). The net effect of this on the subsidy equivalent would be CNY -26.2 billion (A$-4.2 billion), CNY -16.4 billion (A$2.6 billion) and CNY -5.1 billion (A$-0.83 billion) respectively for discount rates of 3, 7 and 11 per cent.

Based on variations in these two assumptions the subsidy equivalent ranges from CNY -26.2 billion (A$-4.2 billion) to CNY 7.8 billion (A$1.3 billion) (table E.11).

Table E.11 **Sensitivity analysis, LSS subsidy equivalent[a]**
China, 2010

Variable	*Units*	*Discount rate*		
		3%	*7%*	*11%*
Annual capital cost	CNY b	14.7	24.5	35.8
Annual generation	TWh	359	359	359
Annual capital cost per unit of generation	CNY/MWh	41	68	100
Operating cost saving per unit of generation[b]	CNY/MWh	78	78	78
Subsidy equivalent	CNY b	-13.3	-3.5	7.8
	A$b	-2.1	0.57	1.3
Alternative operating cost savings scenario (assuming operating cost savings of CNY 114/MWh)[c]				
Subsidy equivalent	CNY b	-26.2	-16.4	-5.1
	A$b	-4.2	-2.6	-0.83

a Assuming that the total capital cost of the plants built to replace plants shut down under the LSS is CNY 317 billion. **b** Based on the assumption that the average size of plants shut down under the LSS was 50 MW. **c** Based on the assumption that the average size of plants shut down under the LSS was 25 MW.

Source: Productivity Commission estimates.

Abatement

If it is assumed that the average size of plants shut down under the LSS is 25 MW (rather than 50 MW) then the counterfactual emissions intensity is 1.28 t CO_2/MWh

(rather than 1.125 t CO_2/MWh). Using this emissions intensity, abatement from the LSS was estimated to be 173 Mt CO_2.

Implicit abatement subsidy

Based on the range of sensitivity analyses conducted above, the Commission has estimated the implicit abatement subsidy of the LSS to be in the range CNY -112 to CNY 66/t CO_2 (A$-18 to A$11) (table E.12).

Table E.12 **Sensitivity analysis, LSS abatement and implicit abatement subsidy**
China, 2010

Variable	*Units*	*Discount rate*		
		3%	7%	11%
Subsidy equivalent[a]	CNY billion	-13.3	-3.5	7.8
Abatement				
Central emissions intensity (1.125 t CO_2/MWh)	Mt CO_2	119	119	119
High emissions intensity (1.278 t CO_2/MWh)	Mt CO_2	173	173	173
Implicit abatement subsidy				
Central emissions intensity	CNY/t CO_2	-112	-29	66
Central emissions intensity	A$/t CO_2	-18	-4.8	11
High emissions intensity	CNY/t CO_2	-76	-203	45
High emissions intensity	A$/t CO_2	-12	-3.3	7.21

[a] The subsidy equivalent is based on the 'central' estimate of the operating cost saving of CNY 78/MWh.

Source: Productivity Commission estimates.

Conclusion

As noted above, the Commission has relied on a number of assumptions in order to estimate the implicit abatement subsidy of the LSS. Some of these assumptions were found to have a material effect on the Commission's estimates. Of particular importance are the interest rate used to estimate the annual capital cost of the LSS, the emissions intensity of the plants shut down under the LSS, and the savings in operating costs from building new plants.

Under most scenarios, the Commission's analysis suggests that the savings in operating costs from the new plants exceed the annualised capital cost of these plants. This leads to negative estimates of the subsidy equivalent and implicit abatement subsidy of the LSS in all but one case. Importantly, setting the discount

rate to a relatively high level (11 per cent) is the only parameter that changes the implicit abatement subsidy from negative to positive.

Moreover, the Commission's estimates of operating cost savings are only based on the fuel cost component of operating costs. It is likely that there would be other operating cost savings associated with new plants, such as maintenance and labour cost, that would imply even greater financial benefits from moving to larger, more efficient plants.

These findings suggest that it would have been cost effective to have pursued the LSS policy even if it did not lead to emissions reductions. Indeed, the LSS program appears to have been implemented for a number of reasons in addition to emissions reductions, including increasing the capacity and efficiency of the electricity supply system, 'energy security', and other environmental reasons.

For example, in 2007, the State Council released the *Notice of the State Council on the Approval and Distribution of the Several Opinions on Speeding up the Closing Down of Small Thermal Power Generating Units from the National Development and Reform Commission and the State Energy Office*. The notice stated that:

> In recent years, the power industry has been developing rapidly. However, improper power structure, especially the high proportion of highly energy-consuming and polluting small thermal power generation units, has become a major bottleneck for energy conservation, emission reduction as well as for the healthy development of the power industry. We must take advantage of the improved power supply-demand situation at present to speed up the closure of small thermal power generating units and accelerate the restructuring of the power industry. This is vital to promote the healthy development of the power industry and achieve the targets for the reduction of energy consumption and emission of major pollutants for the 'Eleventh Five-Year Plan' period. (State Council 2011, p. 1)

In addition, *China's Energy Conditions and Policies* included the LSS program under the category of 'improving the energy supply capacity', noting in regard to efficient electricity generation that:

> It is also a basic requirement for the steady development of the national economy and society to establish an economical, highly efficient and stable power supply system. China will optimize the power supply structure based on structural adjustment. On the basis of taking into overall consideration such factors as resources, technology, environmental protection and the market, the Chinese government will develop clean coal-fired electric power by setting up large coal-fired power bases and encouraging the building of power plants at pitheads, with emphasis on large, highly efficient, environment-friendly power generating sets. (Information Office of the State Council of the PRC (China) 2007, p. 22)

The Commission acknowledges that many of the emissions-reduction policies analysed in this study are characterised by multiple objectives, with no single objective overriding the others. However, the Commission's findings that savings in operating costs outweigh annualised capital costs suggest that the LSS program could be justified on economic grounds alone. The implication is that if production and investment decisions in China's electricity sector were based on market incentives, it is likely that the smaller plants would have been replaced by more efficient plants without government intervention. For this reason, estimates of abatement and the subsidy equivalent from the LSS have not been included in the aggregate estimates for the Chinese electricity sector. Moreover, in chapter 4 of the main report (the electricity generation sector) the negative estimates have been reported as zero. This is because negative numbers are not meaningful in the context of the Commission's analysis.

E.4 Chinese Wind Feed-in Tariffs and Value added Tax exemption

The Chinese Government provides feed-in tariffs (FITs) for wind power generated in China. The FIT rates differ according to where the power is produced. There are four FIT zones, with rates varying from CNY 0.51/kWh – CNY 0.61/kWh (8–10 Australian cents per kWh). The Commission understands that in the past the Guangdong Province had a separate wind power FIT, but that the current rate of the Guangdong FIT is the same as the national rate. For this reason, the Guangdong FIT has been incorporated into the analysis of the national FIT.

In 2002, the Chinese Government announced that the Value-Added Tax (VAT) levied on electricity generated using wind power would be reduced from 17 per cent to 8.5 per cent. At the time, it was suggested that this would lead to a reduction in the average price of wind power of CNY 0.05–0.06/kWh (China Today 2002). The Commission has not been able to access reliable information on how the VAT is levied, or on how the VAT is passed through to consumer electricity prices. Nor does the Commission have information on how the VAT exemption interacts with the FITs. (For example, it could be the case that the FITs would be higher in the absence of the reduced rate VAT). To account for this, the Commission has assumed that the VAT exemption confers an additional benefit on wind power generators of CNY 0.06/kWh. ERI (China) (pers. comm., 25 April 2011) has stated that the assumption that the Commission has made about the treatment of the VAT is a reasonable one.

Estimating the production subsidy equivalent

The Commission was only able to access data on the total generation of wind power in 2010. Data on generation in each of the FIT zones were not available.

However, ERI (China) (pers. comm., 8 April 2011) provided the Commission with data on the installed capacity by region. The Commission has used this data to estimate the capacity installed in each of the tariff zones. The Commission's analysis suggests that the average tariff (weighted by the proportion of installed capacity) was equal to CNY 0.56/kWh (table E.13). The Commission used this figure to estimate the subsidy equivalent for this policy.

The Commission assumed that the counterfactual price of electricity was equal to the average on-grid thermal electricity tariff in China in November 2009 — the most recent period for which data were available. This tariff is equal to 0.381 CNY/kWh (Ma 2011).

Based on these assumptions, the Commission estimated that the production subsidy equivalent from the wind FITs is equal to CNY 179/MWh (A$28.73).

The VAT exemption was assumed to confer an additional benefit of CNY 0.06/kWh, which is equivalent to an additional production subsidy equivalent of CNY 60/MWh (A$9.65/MWh).

Table E.13 **Wind capacity installed by tariff zones**
China, 2010

Tariff region	*Units*	*Zone 1*	*Zone 2*	*Zone 3*	*Zone 4*	*Total*
Tariff rate	CNY/kWh	0.51	0.56	0.58	0.61	..
Installed capacity	GW	9.9	13.4	5.8	15.5	44.7
Proportion of total	%	22	30	13	35	100
Contribution to weighted average tariff	CNY/kWh	0.11	0.16	0.08	0.21	0.56

Sources: ERI (China) (pers. comm., 8 April 2011); Productivity Commission estimates. .. Not applicable

Estimating the subsidy equivalent

Based on the Commission's estimate of the production subsidy equivalent and data on the total generation of wind power in 2010 provided by Vivid Economics (50 100 GWh), the Commission estimated the total FIT revenue paid to wind to be approximately A$1.44 billion, and the total tax expenditure from the VAT exemption to be A$484 million.

The value of the subsidy equivalent depends on the proportion of wind power generation that is attributed to the combined influence of the FIT scheme and the VAT reduction. The Commission has estimated how much wind power was induced by these policies based on an analysis of the history of the wind power sector in China.

There has been a rapid growth in wind power in China over the past 10 years. Vivid Economics provided the Commission with data on the generation of wind power in China since 2005, when total generation was 1300 GWh (approximately 2.5 per cent of 2010 generation). National-level 'wind farm concession tenders' have been in place since 2003 (Ma 2011, p. 2642). These formed the basis of national wind FITs at the time.

In addition to the national-level FITs and the VAT reduction, wind farm investment in China has been promoted by provincial-level policies. This has included preferential FITs for wind power in some provinces. It appears that the national-level policies have had a significant influence on the instruments used by provincial governments to promote wind power, and on the levels of support provided (Ma 2011).

On account of the central role that Chinese Government policies appear to have played in the development of the wind power sector in China, the Commission assumed that the majority of the additional wind power generation since 2001 was induced by the combination of the national FITs and the VAT reduction for wind power. Specifically, the Commission has assumed that 90 per cent of the 2010 wind generation was induced by the combination of the two policies. The remainder of the wind generation was assumed to be either already existing, or installed in response to other policies. The subsidy equivalent and abatement estimates reflect this assumption (table E.14).

Estimating abatement and implicit abatement subsidies

The Commission has estimated the abatement attributable to the wind FITs using the reported national average operating margin as the counterfactual emissions intensity (Michaelowa 2011). This implies abatement of around 45 Mt CO_2 in 2010 (table E.14).

The Commission's estimate of abatement and the subsidy equivalent imply that the implicit abatement subsidy under the Chinese wind FITs and VAT exemption is around A$38/t CO_2.

Sensitivity analysis

The Commission examined the effects of varying two parameters: the emissions intensity of counterfactual electricity generation and the proportion of wind power that is attributed to the FITs. The results (table E.15) show the effects of applying the coal-fired plant 'build margin' from Michaelowa (2011) and the effects of assuming that only 70 per cent of wind power was induced by the FITs and VAT reduction.

Table E.14 **Estimation results, Wind FITs and VAT reduction**
China, 2010

Variable	*Units*	*Value*
Total wind power generation	GWh	50 100
Proportion induced by wind FITs	%	90
Total FIT-induced wind power generation	GWh	45 090
Average FIT	CNY/kWh	0.560
	A$/kWh	0.09
Benefit of VAT reduction	CNY/kWh	0.06
	A$/kWh	0.01
Average on-grid electricity tariff	CNY/kWh	0.381
Production subsidy equivalent	CNY/MWh	239
	A$/MWh	38
Subsidy equivalent	CNY b	10.8
	A$b	1.7
Abatement	Mt CO_2	45
Implicit abatement subsidy	CNY/t CO_2	238
	A$/t CO_2	38

Sources: Vivid Economics, Productivity Commission estimates.

Table E.15 **Sensitivity analysis, Wind FITs and VAT exemption**
China, 2010

Scenario	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*	
	A$b	Mt CO_2	A$/t$CO_2$	CNY/t CO_2
'Central' estimate	1.73	45.2	38	238
Michaelowa (2011) 'build margin' emissions counterfactual	1.73	36.3	48	296
70 per cent of wind induced by FITs and VAT	1.35	35.2	38	238

Source: Productivity Commission estimates.

E.5 Jiangsu PV Feed-in Tariffs

The Jiangsu photovoltaic (PV) FITs were introduced in June 2009. FIT rates are set through a bidding process, and the Chinese Government has 'targets' for the FIT rates each year. There are differential FIT rate targets for PV solar farms, rooftop PV and 'building integrated PV' (2010 FIT targets are CNY 1.7, 3.0 and 3.5 per kWh respectively). The objective of the policy is to have 400 MW of solar PV capacity installed by the end of 2011, comprising 260 MW of rooftop projects, 10 MW of building integrated PV projects and 130 MW of solar PV farms. Prior to the announcement of the policy, installed PV in Jiangsu province was likely to be small (around 3 MW) (Renewable Energy and Energy Efficiency Partnership 2010). For simplicity, the Commission has assumed that 100 per cent of Jiangsu solar PV was induced by the FITs. This is likely to overstate the subsidy equivalent and abatement by less than 2 per cent.

Estimating the subsidy equivalent

Estimating the subsidy equivalent involves estimating the amount of electricity generated that is eligible to receive the FITs, and then estimating the total FIT revenue and counterfactual revenue.

Estimating electricity generation

In order to estimate the electricity generation from eligible PV in Jiangsu province, it was necessary to make a number of assumptions. The Commission has assumed that:

- the policy runs from June 2009 to the end of 2011, and meets targets for installations in each of the three sectors
- installations of solar PV are spread evenly across this 31-month period
- the output of the installed solar PV systems is equal to the assumptions used in the IEA Solar PV Roadmap (IEA 2010m):
  - PV solar farm output is equal to IEA 'utility sector' output of 1650 kWh per kW per year
  - rooftop PV output is equal to IEA 'residential sector' output of 1300 kWh per kW per year

  - building integrated PV output is equal to IEA 'commercial sector' output of 1450 kWh per kW per year[2]
- the output of PV systems is evenly spread over the year (this assumption is likely to overstate the total output of systems installed in the second half of 2010, because winter output is likely to be lower than summer output).

The Commission used these assumptions to estimate the cumulative installations of each type of plant over the period June 2009 to December 2010. Based on estimates of installations, the Commission estimated the monthly output of FIT-eligible electricity. The results of the Commission's analysis suggest that the total output of FIT-eligible PV systems in 2010 would be around 247 GWh (table E.16).

Estimating FIT revenue and counterfactual revenue

The revenue received from FITs was estimated by multiplying the output of FIT-eligible PV by the relevant FIT rates. The Commission assumed that FIT rates are equal to the Chinese Government's 'targets'. The counterfactual revenue is estimated as the 2009 average 'benchmark on-grid electricity tariffs of coal fired plants' for the Jiangsu Province — CNY 0.43/kWh reported in Ma (2011). This is different from the national average benchmark tariff that is used for other policies, because the policy is specific to Jiangsu province. By subtracting the counterfactual revenue from the FIT revenue, the subsidy equivalent for each type of PV installation, and a subsidy equivalent for the policy as a whole, was estimated (table E.16).

Table E.16 **Estimated electricity production, and subsidy equivalents, Jiangsu PV FITs**

China, 2010

	Units	*PV Solar farm*	*Rooftop PV*	*BIPV* [a]	*Total*
Cumulative installation to 2010	MW	79.7	159.4	6.1	245.2
2010 electricity output	GWh	93	147	6.3	247
FIT revenue	CNY m	159	442	22	622
Counterfactual revenue	CNY m	40.2	63.3	2.7	106.2
Subsidy equivalent	CNY m	118.6	378.3	19.4	516.3
	A$m	19.1	60.9	3.1	83.1

[a] Building-integrated PV.

Sources: IEA (2010m); Ma (2011); Productivity Commission estimates.

[2] These figures imply capacity factors of 19 per cent for solar PV farms, 15 per cent for rooftop PV and 17 per cent for BIPV. These are consistent with other published estimates of the capacity factor of solar PV systems.

Abatement

The Commission based its estimate of the abatement attributable to the Jiangsu PV FITs on the estimated 'operating margin emission factor' for the Eastern Grid (which includes Jiangsu province). The estimate for December 2010 is 0.8592 t CO_2/MWh (Michaelowa 2011). Using this number leads to an estimate of 212 kt of CO_2 abated through this policy in 2010 (table E.17).

Implicit abatement subsidy

Using estimates of the subsidy equivalent and the abatement attributable to the policy, it is possible to estimate the implicit abatement subsidy delivered by this policy. The overall estimate is around CNY 2434/t CO_2 (A$391) (table E.17).

Table E.17 **Abatement and implicit abatement subsidy, Jiangsu PV FITs**

China, 2010

	Units	*PV solar farm*	*Rooftop PV*	*BIPV* [a]	*Total*
Abatement	Mt CO_2	0.08	0.13	0.005	0.2
Implicit abatement subsidy	CNY/t CO_2	1 478	2 991	3 573	2 434
	A$/t CO_2	238	481	575	391

[a] Building-integrated PV.

Sources: Michaelowa (2011); Productivity Commission estimates.

Sensitivity analysis

The Commission carried out sensitivity analysis on several parameters. The first was increasing and decreasing the counterfactual emissions factor by 10 per cent. This is slightly different from the sensitivity analysis carried out for other Chinese policies, because the 'central' estimate is based on the counterfactual emissions factor for the Eastern Grid (0.86 t CO_2/MWh) rather than the national average (1.003 t CO_2/MWh). Varying the emissions factor by 10 per cent leads to a proportional change in abatement, and a proportional change in the implicit abatement subsidy (table E.18).

Table E.18 **Sensitivity analysis, Jiangsu PV FITs**
China, 2010

Scenario	*Subsidy equivalent (SE_i)*	*Δ SE_i*	*Abatement (A_i)*	*Δ A_i*	*Implicit abatement subsidy (s_i)*	*Δ s_i*
	A$ (million)	%	Mt CO_2	%	A$/t CO_2	%
'Central' case	83		0.21		391	
Higher counterfactual emissions intensity (0.95 t CO_2/MWh)						
			0.23	10	356	-9.1
Lower counterfactual emissions intensity (0.77 t CO_2/MWh)						
			0.19	-10	435	11.1

Source: Productivity Commission estimates.

E.6 Chinese Biomass Feed-in Tariffs

Since 2006, China has provided feed-in tariffs to grid-connected biomass installations. Initially, this feed-in tariff was provided on top of the tariff paid to coal-fired generation, and was set at CNY 0.25/kWh with an additional CNY 0.10/kWh for direct combustion biomass (ERI (China) 2010).

In 2009, the rate was amended upwards to CNY 0.35/kWh. The scheme was again amended in July 2010, to provide a set feed-in tariff of CNY 0.75/kWh (this is no longer provided on top of the coal tariff). All projects previously approved for the feed in tariffs are entitled to use this new rate (Ma 2011).

In analysing the feed-in tariffs, the Commission has used:

- the 2010 feed-in tariff rate (the average of the rate before and after the rate change in July 2010)
- 2010 generation estimates.

Estimating the subsidy equivalent

The production subsidy equivalent was calculated by averaging:

- the post-July 2010 premium rate — estimated by subtracting the counterfactual electricity price from the preferential tariff received (CNY 0.75/kWh). As noted in section E.1, the counterfactual price is assumed to be the November 2009 average benchmark coal tariff rate (CNY 0.381/kWh) (Ma 2011). Therefore, the premium rate is CNY 0.369/kWh
- The pre-July 2010 premium rate — as this was provided on top of the coal tariff, this is simply the rate of the tariff (CNY 0.35/kWh).

Therefore, the production subsidy equivalent was estimated as CNY 0.36/kWh.

According to the ERI (China) (pers. comm., 25 April, 2011) in 2010 there was 4.5 GW of biomass installed, generating an estimated 11.3 TWh of electricity. In 2005, before the biomass FITs commenced, there were 2 GW of capacity generating an estimated 5.2 TWh of electricity (ERI (China) pers. comm., 26 April 2011). The Commission assumed that additional generation since 2005 has been 'induced' by the FITs. Therefore, the biomass FITs are estimated to have 'induced' 6.1 TWh of biomass electricity generation.

By multiplying the 'induced' generation receiving the feed-in tariffs, by the production subsidy equivalent they received, the subsidy equivalent is estimated to be CNY 2.2 billion (A$353 million).

Table E.19 **Estimating the subsidy equivalent, Biomass FITs**
China, 2010

Data	*Value*
Biomass generation from capacity installed between 2006 and 2009	6.1 TWh
Production subsidy equivalent	CNY 0.36/kWh
Subsidy equivalent (CNY)	CNY 2.2b
Subsidy equivalent (A$)	A$353m

Source: Productivity Commission estimates.

Estimating abatement

As noted in section E.1, the marginal emissions intensity of the Chinese grid on average was estimated to be 1.003 t CO_2/MWh. The Commission has assumed that, on average, this is what the additional biomass generation displaced in 2010. In addition, the Commission has assumed that the additional biomass generation has zero net emissions. Therefore, the estimate of abatement due to the biomass FITs in 2010 is 6.1 Mt CO_2.

The implicit abatement subsidy

The implicit abatement subsidy was calculated by dividing the subsidy equivalent by the abatement induced by the policy. This implies an implicit abatement subsidy of CNY 358/t CO_2 (A$58).

Sensitivity analysis

The Commission made a range of assumptions when calculating the above estimates. This section provides sensitivity analysis around these assumptions.

Altering the counterfactual

As noted in section E.1, the operating margin used for the Chinese grid may be an overestimate of the actual marginal grid intensity. Therefore, a scenario with a counterfactual emissions intensity of 0.804 t CO_2/MWh was used (as per the Michaelowa (2010) build margin).

This reduces the abatement attributable to the biomass feed in tariffs, and as a result, an increase in the implicit abatement subsidy to CNY 447/t CO_2 (A$72).

Reduced VAT for biomass

The Commission is aware that some biomass generation receives a full refund on its VAT liability. The exemption appears to only apply to municipal waste generation. Data were not available on the amount of biomass that is municipal waste, and therefore this policy is only factored into the sensitivity analysis. The standard VAT rate is 17 per cent

In order to receive the estimated (after VAT) tariff of CNY 0.74/kWh (the average of the pre- and post-July 2010 tariffs), a generator paying a 17 per cent VAT would have to receive a (pre-tax) tariff of CNY 0.89/kWh. Therefore, the production subsidy for VAT exempt generators is CNY 0.89 minus the coal tariff (CNY 0.381) which is equivalent to CNY 0.51/kWh.

The Commission assumed that 25 per cent of biomass production is municipal waste, and therefore receives the reduced VAT. This leads to an increased subsidy equivalent for biomass of CNY 2.5 billion, and a higher implicit abatement subsidy of CNY 403/t CO_2 (A$65).

Summary

The results of the estimation are displayed in table E.20. The estimates of the implicit abatement subsidy range from approximately CNY 358 to CNY 447/t CO_2 (A$58–A$72).

Table E.20 **Summary, Biomass FITs**
China, 2010

Scenario	*Subsidy equivalent*		*Abatement*	*Implicit abatement subsidy*	
	A$m	CNY b	Mt CO_2	A$/t CO_2	CNY/t CO_2
'Central' scenario	353	2.2	6	58	358
Lower counterfactual intensity	353	2.2	5	72	447
VAT exemption for municipal waste	397	2.5	6	65	403

Source: Productivity Commission estimates.

E.7 Subsidy for Solar PV in Buildings

In 2009, the Chinese Government introduced a capital subsidy for the installation of solar PV in buildings. This subsidy supported both building-integrated PV (CNY 20/W) and other grid-connected PV (CNY 15/W) (Martinot and Junfeng 2010). To be eligible for the subsidy, installations must be more than 50 kW.

In 2010, these rates were reduced to CNY 17/watt for building-integrated PV and CNY 13/watt for other grid connected PV (Martinot and Junfeng 2010).

Estimating the subsidy equivalent

According to the ERI (China) (pers. comm., 15 April 2011), as of 2009, CNY 836 million has been paid out under the scheme. This has been converted to 2010 CNY. As a result of this, the total outlay (in 2010 CNY) is estimated at CNY 885 million.

Using a discount rate of 7 per cent, and an expected economic life of the assets of 20 years, the Commission estimated the annualised subsidy (the subsidy equivalent) to be CNY 83.5 million (A$13.4 million) (table E.21).

Table E.21 **Subsidy equivalent, Subsidies for Solar PV in Buildings**
China, 2010

	Units	*Value*
Estimated subsidy (2010 CNY)	CNY	885m
Discount rate	per cent	7
Expected lifetime of assets	years	20
Subsidy equivalent	**CNY**	**83.5m**
Subsidy equivalent	**A$**	**$13.4m**

Source: Productivity Commission estimates.

Abatement

As of the end of 2009, this subsidy had subsidised 91 MW of solar PV (ERI (China), pers. comm., 17 April 2011). The Commission assumed that the majority of these installations are 'commercial' sized, and therefore a capacity factor of approximately 17 per cent is appropriate (IEA 2010m). Using this capacity factor results in an estimate of annual generation from the subsidised solar PV of 132 GWh.

Using an estimate of the operating margin of the Chinese grid of 1.003 t CO_2/MWh (Michaelowa 2011) (section E.1), the Commission has estimated abatement of the subsidies for PV in buildings scheme to equal 132 kt CO_2.

Table E.22 **Abatement, Subsidies for Solar PV in Buildings**
China, 2010

	Value
Capacity supported	91 MW
Capacity factor	17 per cent
Annual generation	132 GWh
Counterfactual emissions intensity	1.003 t CO_2/MWh
Abatement	0.13 Mt

Sources: IEA (2010m); Productivity Commission estimates.

Implicit abatement subsidy

Using the above estimates, the implicit abatement subsidy is estimated to be CNY 631/t CO_2 (A$102).

Sensitivity analysis

To analyse the effects of the assumptions used to calculate the above estimates, the Commission varied the discount rate and the emissions intensity of the counterfactual source.

Varying the discount rate

Two alternate discount rates were used.

- Using a discount rate of 11 per cent resulted in an implicit abatement subsidy of CNY 840/t CO_2 (A$135).

- Using a discount rate of 3 per cent resulted in an implicit abatement subsidy of CNY 449/t CO_2 (A$72).

Varying the counterfactual

As noted in section E.1, the Commission is using the Chinese build margin of 0.804 t CO_2/MWh as a sensitivity analysis parameter. This led to the 'low' estimate of abatement, and an implicit abatement subsidy of CNY 787/t CO_2 (A$127).

Summary

Table E.23 outlines the results for the Subsidy for Solar PV in Buildings scheme. The implicit abatement subsidy estimates range from CNY 449 to CNY 840/t CO_2 (A$72 – A$135).

Table E.23 **Summary, Subsidy for Solar PV in Buildings**
China, 2010

Scenario	*Subsidy equivalent*		*Abatement*	*Implicit abatement subsidy*	
	A$m	CNY m	Mt CO_2	A$/t	CNY/t CO_2
'Central'	13.4	84	0.13	101	631
Discount rate of 11 per cent	17.9	111	0.13	135	840
Discount rate of 3 per cent	9.6	59	0.13	72	449
Counterfactual emissions intensity of 0.804	13.4	84	0.11	127	787

Source: Productivity Commission estimates.

E.8 Golden Sun Demonstration scheme

The Golden Sun Demonstration Scheme provides a subsidy to selected solar PV projects. The value of the subsidy is either 50 per cent of the investment for grid connected PV, or 70 per cent of the investment for off-grid PV.

In order to qualify for a subsidy under the Golden Sun scheme, generators must meet a range of criteria, including:

- installed capacity must be at least 300 kW
- total investment must be greater than CNY 100 million (A$16 million)
- various technical requirements.

In November 2009, the Chinese Government released a list of 275 projects to be supported by the Golden Sun scheme (MoF (China) 2009).

Estimating the subsidy equivalent

According to Wang (2009), the Chinese Government has announced that 642 MW of solar capacity will be supported by the scheme, at a total construction cost of CNY 20 billion.

The Commission was unable to access data on the subsidies offered under the scheme, and has therefore assumed that the scheme provided a subsidy of 60 per cent of construction costs for the average project (the average of the subsidy for off- and on-grid generators). Therefore, the subsidy to be offered by the scheme is estimated at CNY 12 billion.

As the Golden Sun scheme was expected to last for three years, it was assumed that one third of the capacity was built in 2010. Therefore, the subsidy granted by the scheme up until the end of 2010 was estimated to be CNY 4 billion.

Using a discount rate of 7 per cent, and an expected economic lifetime of 20 years, this subsidy was annualised over the lifetime of the assets. The annualised subsidy equivalent is estimated to be CNY 378 million (A$60.7 million) (table E.24).

Table E.24 **Golden Sun Demonstration scheme, subsidy equivalent**
China, 2010

	Value
Estimated subsidy granted in 2010	CNY 4b
Discount rate	7 per cent
Expected lifetime of assets	20 years
Annualised subsidy	CNY 378m
Subsidy equivalent	A$60.7m

Source: Productivity Commission estimates.

Estimating abatement

As noted above, 642 MW of solar is expected to be supported by the scheme, and the Commission assumed that one-third of this was installed in 2010. Therefore, the Commission has estimated 214 MW of solar capacity has been supported by the scheme as of the end of 2010.

MoF (China) (2009) outlines the generators that are to be supported by the scheme. Of this, 46 MW were classed as 'in areas without electricity'. The Commission has also assumed that one third of this capacity was built in 2010, leading to an estimate of 15 MW of off-grid capacity built under the scheme.

The IEA (2010m) suggests that the average capacity factor of solar PV is approximately 19 per cent. Using this capacity factor, the annual generation from 214 MW of solar is estimated at 353 GWh, of which 25 GWh was off grid.

A different counterfactual emissions intensity has been applied to on-grid and off-grid solar:

- For on-grid solar, the counterfactual emissions intensity outlined in Michaelowa (2011) (section E.2) was used. This results in abatement from the Golden Sun on-grid capacity of 329 kt CO_2.
- It is not appropriate to use an operating margin for off-grid electricity (as it is not displacing any currently operating generation). Rather, a build margin is used — which estimates the marginal generator that is *built* in China. This is appropriate because it relates to the generator the would have been built if the solar PV was not built. In 2010, the build margin for coal is estimated at 0.804 t CO_2/MWh (Michaelowa 2011). This leads to an abatement estimate of 20 kt CO_2 from off-grid generation.

Combined, this results in an estimated 349 kt of abatement from the Golden Sun Demonstration scheme (table E.25).

Table E.25 **Golden Sun Demonstration scheme, abatement**
China, 2010

	Units	*On grid*	*Off grid*	*Total*
Estimated capacity installed in 2010	MW	199	15	214
Capacity factor	%	19	19	19
Annual generation of subsidised solar PV	GWh	328	25	353
Counterfactual emissions intensity	t CO_2/MWh	1.003	0.8	
Abatement	Mt CO_2	0.33	0.02	0.35

Sources: IEA (2010m); Wang (2009); Productivity Commission estimates.

Implicit abatement subsidy

Based on the above estimates, the implicit abatement subsidy was estimated to be CNY 1081/t CO_2 (A$174).

Sensitivity analysis

Varying the discount rate

Two alternate discount rates were used:

- Setting the discount rate at 11 per cent led to an increase in the estimated subsidy equivalent, and reduced the implicit abatement subsidy to CNY 1438/t CO_2 (A$231).
- Setting the discount rate at 3 per cent led to an increase in the estimated subsidy equivalent, and reduced the implicit abatement subsidy to CNY 770/t CO_2 (A$124).

Varying the counterfactual emissions intensity

As noted in section E.1, the Commission used the average build margin of Chinese coal plants (0.804 t CO_2/MWh) as an alternative counterfactual emissions intensity. This resulted in a lower estimate of abatement, and therefore an increase in the implicit abatement subsidy to CNY 1330/t CO_2 (A$214).

Varying the subsidy percentage

As noted above, it is unclear what percentage of the construction costs are subsidised. As many of the generators appear to be on-grid, the actual percentage of the construction costs subsidised may be closer to 50 per cent — which is the subsidy offered for on-grid installations.

Using a subsidy percentage of 50 per cent (as opposed to 60 per cent) decreases the subsidy equivalent, and thus leads to a decrease in the implicit abatement subsidy to CNY 901/t CO_2 (A$145).

Summary

Table E.26 outlines the results of the estimation of the Golden Sun Demonstration scheme. The implicit abatement subsidy estimates range from CNY 770 to CNY 1438 (A$124 to A$231).

Table E.26 **Summary, Golden Sun Demonstration scheme**
China, 2010

Scenario	*Subsidy equivalent*		*Abatement*	*Implicit abatement subsidy*	
	A$m	CNY m	Mt CO_2	A$/t	CNY/t
'Central'	60.7	378	0.35	174	1 081
High discount rate	80.8	502	0.35	231	1438
Low discount rate	43.2	269	0.35	124	770
Counterfactual emissions intensity of 0.804t CO_2/MWh	60.7	378	0.28	214	1330
Decreasing the percentage subsidy to 50 per cent	50.6	315	0.35	145	901

Source: Productivity Commission estimates.

E.9 Summary

This section sets out the Commission's estimates of the total subsidy equivalent of the policies that were analysed for China, and the total abatement that can be attributed to the suite of electricity generation sector policies.

The total subsidy equivalent

The estimates of the subsidy equivalent for each policy can be added together to estimate the total subsidy equivalent for all policies analysed. The resulting estimates are between CNY 11.4 billion and CNY 14.4 billion (A$1.8 billion and A$2.3 billion) (table E.27) and represents between 0.03 to 0.04 per cent of China's GDP taking into account the sensitivity analysis.

Total abatement

In some cases, the estimated abatement 'induced' by a policy may overlap with other policies, and therefore these estimates can not simply be added together. In two cases, a policy is targeted at clearly distinct abatement opportunities, and individual policy abatement estimates can be added together:

- Biomass — Biomass Feed-in Tariffs
- Wind — Wind Feed-in Tariffs.

Table E.27 **The estimated total subsidy equivalent**
China, 2010

Policy	*Australian dollars*			*Chinese Yuan*		
	'Central'	*High*	*Low*	*'Central'*	*High*	*Low*
	A$m	A$m	A$m	CNY b	CNY b	CNY b
Wind FITs	1 731	1 731	1 346	11	11	8
Biomass FITs	353	397	353	2.2	2.5	2.5
Jiangsu Solar PV FITs	83	83	83	0.5	0.5	0.5
Golden Sun Demonstration scheme	61	81	43	0.4	0.5	0.3
Subsidies for PV in Buildings	13	18	10	0.1	0.1	0.1
Total	2 241	2 309	1 835	13.9	14.4	11.4

Source: Productivity Commission estimates.

However, three polices — the Golden Sun Demonstration scheme, subsidies for PV in buildings, and the Jiangsu FITs — are all targeted at solar PV. The Commission considers that:

- it is unlikely that there would be any overlap between the Golden Sun scheme, and the Solar PV in Buildings scheme — the Golden Sun scheme appears to be targeted at large scale demonstration projects, whereas the Solar PV in Buildings scheme is targeted at smaller scale PV generation
- there may be some limited overlap between the capital subsidy schemes and the Jiangsu FITs. Data were not available on the extent to which this may be the case. However for sensitivity analysis, 20 per cent of the abatement in the Jiangsu FITs was assumed to overlap with the capital subsidies, and was removed from the 'low' abatement scenario.

Taking this into account, estimated abatement ranges from 41 to 52 Mt CO_2 (table E.28).

Table E.28 **Total abatement**
China, 2010

Policy	*'Central'*	*High*	*Low*
	Mt CO_2	Mt CO_2	Mt CO_2
Wind FITs	45.2	45	35.2
Biomass FITs	6.1	6	4.9
Jiangsu Solar PV FITs	0.2	0.2	0.2
Golden Sun Demonstration scheme	0.3	0.3	0.3
Subsidies for PV in Buildings	0.1	0.1	0.1
Total	52.0	52	40.7

Source: Productivity Commission estimates.

Total abatement as a proportion of total emissions

The most recent data that the Commission was able to obtain on Chinese electricity generation sector emissions were from 2005, when emissions were estimated at around 2100 Mt CO_2. Over the period 2005–09, conventional thermal electricity generation rose by around 45 per cent (EIA (US) 2011k). Given that most electricity sector emissions arise from conventional thermal generation, electricity sector emissions can be estimated at around 3063 Mt CO_2 in 2009. Projecting forward, if thermal electricity generation continued to grow at similar rates (around 10 per cent per year), total electricity sector emissions may have been around 3370 Mt CO_2 in 2010.

This estimate puts the estimates of total abatement into context. The Commission estimated that the policies that have been assessed led to abatement of around 52 Mt CO_2 in 2010. This represents between 1 to 2 per cent of China's estimated counterfactual emissions from electricity in 2010 .

The average implicit abatement subsidy

Using the estimates outlined above, the Commission estimated an average implicit abatement subsidy for the Chinese electricity sector of between CNY 219/t CO_2 and CNY 353/t CO_2 (A$35 and A$57) (table E.29).

Table E.29 **Average implicit abatement subsidy**
China, 2010

	Abatement					
	Australian Dollars			*CNY*		
Subsidy equivalent	*'Central'*	*High*	*Low*	*'Central'*	*High*	*Low*
	A$/t CO_2	A$/t CO_2	A$/t CO_2	CNY$/t CO_2	CNY$/t CO_2	CNY$/t CO_2
'Central'	44	44	57	276	276	353
High	43	43	55	268	268	343
Low	35	35	45	219	219	280

Source: Productivity Commission estimates.

If abatement from the LSS program were to be included in the estimates of total abatement, the value of the implicit abatement subsidy would fall to between CNY 67–90/t CO_2 (A$8 and A$15).

E.10 Other Chinese electricity generation policies

Excluded policies

The following policies have not been included in the analysis:

- Household Biogas Project — Assistance to farmers for the installation of biogas digesters. Excluded because this policy subsidises heat generation, not electricity generation.
- Shandong Province Village renewable energy regulations — Subsidies for specified renewable energy technologies in the Shandong Province. This program is probably not material relative to other policies.
- Feed in tariffs for grid connected PV in Inner Mongolia and Shanghai Chongmingdao. This program is probably not material relative to other policies.
- Preferential tax policies for renewable energy — Reduced income tax rates for foreign investment in biogas and wind generation. Excluded because it is not clear how this policy operates, and whether it provides a subsidy for renewable electricity capacity installation and generation, or for the manufacture of renewable energy assets.
- Preferential tax rates for small hydro generation — Small hydro producers can elect to pay a reduced rate of VAT. This program is probably not material relative to other policies.

In some cases, the Commission was unable to locate the data required to estimate implicit abatement subsidies. Such policies include:

- preferential loans for renewable energy projects
- restrictions on loans for high-emitting facilities — commercial banks are required to curb lending to high-emitting or high-energy using facilities
- the prohibition of the construction of new coal and gas-fired units — this policy appears to be a restriction on small-scale coal- and gas-fired generation attached to industrial facilities.

While the Commission's analysis is limited to a subset of the policies that could influence emissions in China's electricity generation sector, the Commission considers that the policies that have been analysed provide a useful indication of the type of policies that are being pursued, the subsidies they provide for low-emissions generation and the abatement that is being achieved.

Committed policies

The Chinese Government's 12th Five Year Plan covers the period 2011–2015, and contains a number of targets that are related to greenhouse gas emissions from the Chinese electricity generation sector. These include:

- energy consumption per unit of GDP to be cut by 16 per cent
- CO_2 emissions per unit of GDP to be cut by 17 per cent
- non-fossil fuel to account for 11.4 per cent of primary energy consumption (Xinhuanet 2011).

There is little detail on how these targets will be achieved, although media reporting suggest that the Chinese Government is proposing to trial the introduction of some form of emissions trading scheme in six provinces before 2013 and nationwide by 2015 (Reuters 2011).

F Germany's electricity generation sector

The Commission has estimated the subsidy equivalent, abatement and implicit abatement subsidies for three policies in Germany: the European Union Emissions Trading Scheme (ETS), the *Renewable Energy Sources Act* (RES Act) and the *Combined Heat and Power Act* (CHP Act).

Several other policies were considered, but preliminary analysis suggested that the effect of these policies on the total subsidy equivalent and abatement was unlikely to be material in comparison to the other policies analysed.

The year of analysis varied for each policy for data reasons. The subsidy equivalent and abatement attributable to the European Union ETS were estimated for 2010. But for the RES and CHP Acts, the most recent year for which the Commission was able to obtain data was 2009. Subsidy equivalents were estimated for 2009, and results were deflated to 2010 values. The exchange rate used was the 2010 average A$/Euro exchange rate of 0.698. Data were deflated using the German GDP deflator for 2009–2010 (1.007).

For the three policies that were analysed in detail, the Commission carried out sensitivity analysis. The results of the sensitivity analysis are reported in comparison to the Commission's 'central' estimate. The 'central' estimate is based on the set of assumptions that the Commission considers to be most consistent with its approach to estimating subsidy equivalents and abatement.

References in this appendix to Vivid Economics and Frontier Economics refer to unpublished data supplied to the Productivity Commission by that contractor. The relevant data are provided on the Commission's website, where there are no commercial-in-confidence restrictions.

F.1 Electricity generation in Germany

Structure of Germany's electricity markets

According to Sensfuß (2007), four companies (E.On, RWE, Vattenfall Europe and EnbW) own 90 per cent of Germany's electricity generation capacity. Electricity can be traded through long-term bilateral over-the-counter transactions between generators and purchasers (such as retailers and large users of electricity), and on energy markets through the European Energy Exchange. Generators make bids to supply electricity in hourly blocks. The European Energy Exchange manages a number of different markets, including day-ahead auctions and 'intraday' auctions that operate at shorter intervals (Ockenfels et al. 2008). Generators make bids to supply a given amount of electricity into the grid during a given interval, and the market-clearing price is determined based on the marginal bidder (the lowest-price bid that is required to meet total demand for a given period). All generators receive the marginal bid as the electricity price (the auction is a 'uniform price auction').

Electricity transfers

Germany's electricity transmission system is connected to neighbouring countries, and Germany participates in some cross-border electricity trade. The Commission was not able to access recent data on net trade in electricity. However, in 2007 Germany was a small net exporter of electricity (imports of 33 TWh and exports of 45 TWh). The main import sources were France, Switzerland, the Czech Republic and Denmark, while the main export destinations were the Netherlands, Austria and France (RWE 2008).

Germany's nuclear phase-out

The German Government has chosen to phase out the use of nuclear power in Germany. Following a period of negotiation with the electricity industry, the nuclear industry signed an agreement with the government in 2000. A law to phase out nuclear power was passed in 2002. The building of new plants was banned, and existing generators were allocated a 'budget' that permitted the plants to generate electricity equivalent to 32 years of generation at full utilisation over the life of the plant (including electricity already generated) (Sensfuß 2007). Under this schedule at least two of Germany's 17 nuclear reactors were scheduled to be shut down in 2010 (Ackland 2010).

The current German Government has maintained the ban on building new nuclear plants, but has extended the schedule for closing existing plants. There is uncertainty regarding when the plants will be closed.

Key statistics

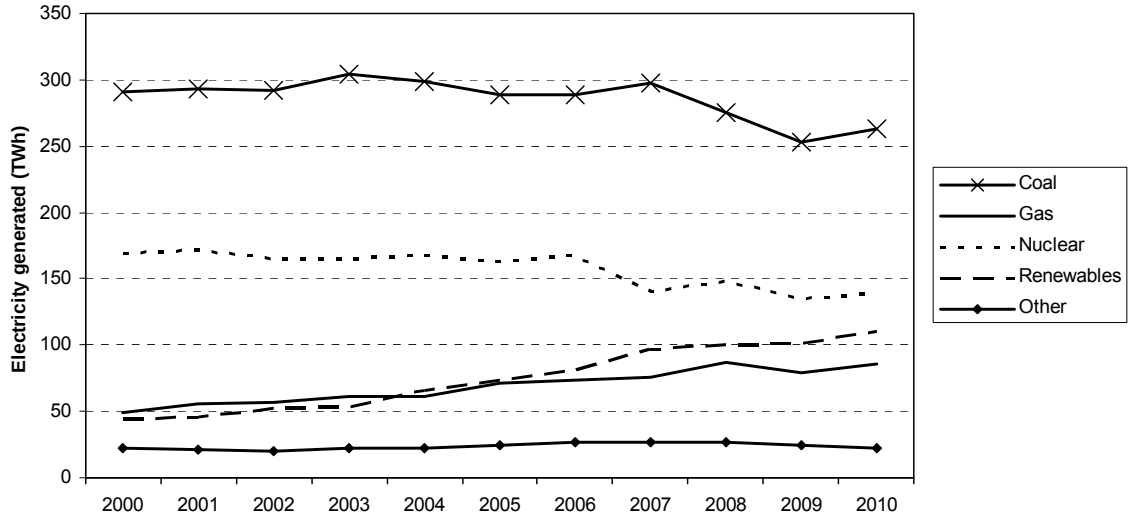
Electricity prices

Average German wholesale electricity prices were around €68.80/MWh (A$121) in 2009 and €52.60/MWh (A$75) in 2010 (Vivid Economics).

Electricity generation

The majority of Germany's electricity is generated through fossil-fuel combustion (hard (black) coal, lignite, natural gas and oil), nuclear energy, and renewable energy (figure F.1). Coal accounted for around 42 per cent of Germany's generation in 2010, nuclear energy for around 23 per cent, and gas for around 13 per cent. In total, renewables accounted for around 17 per cent of Germany's electricity generation in 2010. Wind, hydro and biomass were the major sources of renewable energy (table F.1).

Figure F.1 **Electricity generated by fuel type[a]**
Germany 2000–2010



a 'Other' includes oil and other small-scale fuel sources.

Source: Frontier Economics (unpublished data).

Table F.1 **Renewable generation[a]**
Germany, 2010

Renewable energy source	*Generation (TWh)*	*% of total renewable generation*
Wind	38	34
Hydro	26	23
Biomass	29	26
Solar photovoltaic	12	11
Waste	7	6
Total renewable generation	110	100

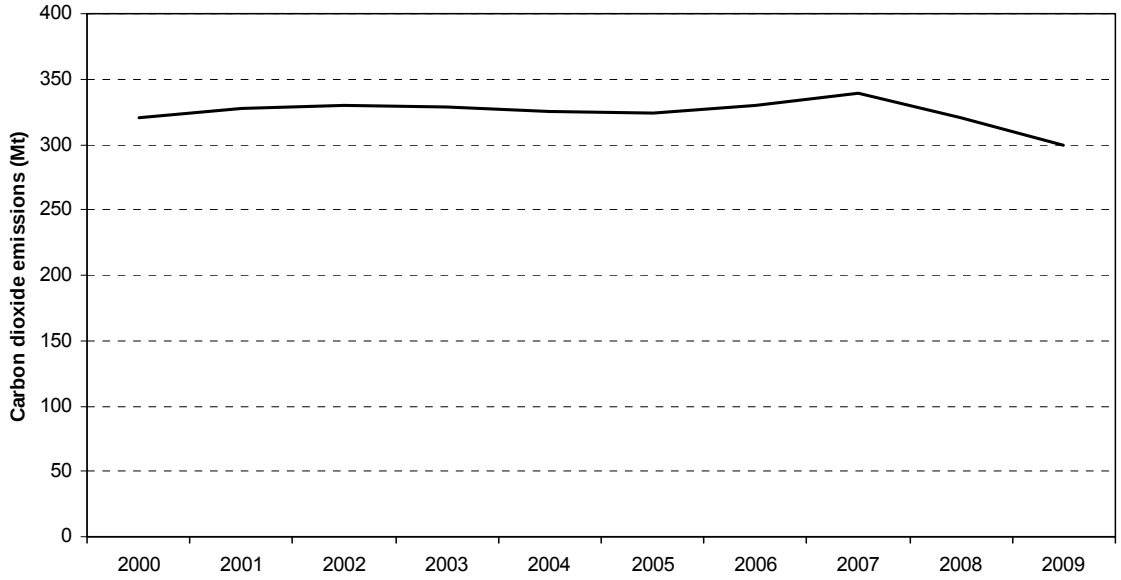
a Does not include 'other' energy sources.

Source: Frontier Economics (unpublished data).

Emissions

Emissions from Germany's electricity sector have fallen since 2000, despite a slight increase in overall electricity use (577 TWh in 2000 and 593 TWh in 2009) (figure F.2). The reduction in emissions can mainly be attributed to a reduction in the use of coal, and an increase in the use of gas and renewables (table F.2).

Figure F.2 **Emissions, electricity generation**
Germany, 2000–2009



Source: Frontier Economics (unpublished data).

Table F.2 **Emissions intensity of electricity generation**
Germany, 2009

Electricity source	*Emissions intensity (t CO_2/MWh)*
Lignite — old	1.17
Lignite — new	0.93
Hard coal — old	1.07
Hard coal — new	0.79
Natural gas — gas turbine	0.57
Natural gas — steam turbine	0.49
Natural gas — combined cycle	0.39
Heavy oil — gas turbine	0.84
Heavy oil — steam turbine	0.73
Electricity sector average (2009)	0.50

Sources: Traber and Kemfert (2009); Frontier Economics (unpublished data).

F.2 Estimating abatement in Germany

For each of the three German policies that have been analysed, the Commission has used different emissions counterfactuals to estimate abatement:

- For the RES Act, the Commission has based its estimate of abatement on published estimates of the 'substitution factors' for each type of renewable energy that is subsidised under the Act.
- For the CHP Act, the Commission has estimated the saving in emissions that would have occurred if heat was generated directly, rather than through CHP.
- For the European Union ETS, the Commission has estimated the abatement arising from a switch from coal to gas.

Where relevant, the Commission has used the emissions factors in table F.2 to estimate abatement.

F.3 The Renewable Energy Sources Act

The German *Renewable Energy Sources Act* (RES Act) (*Erneuerbare Energien Gesetz*) obliges electricity grid system operators to pay legislated feed-in tariffs (FITs) for electricity generated using certain renewable energy sources. The FITs vary according to the technology used, and the size and age of the plant. In general, for a given technology, smaller plants attract larger FITs, and for some technologies FITs are higher for the first five to twelve years after installation. For most renewable energy sources, the tariffs are of the order of €0.05–0.12 (A$0.07–0.17)

per kilowatt hour (kWh). The most generous tariffs are granted to offshore wind energy (€0.13/kWh (A$0.19)), geothermal energy (€0.16/kWh (A$0.23)), and solar energy (up to €0.43/kWh (A$0.62)).

Estimating the subsidy equivalent

The Commission used data on the total FIT payments to each eligible technology and the wholesale electricity price in 2009 to estimate the subsidy equivalent. Results were converted into 2010 Australian dollars. Data sources and assumptions are described below, the calculations are set out in table F.3, and the estimates are presented in table F.4.

Annual generation and total FIT payments by source

For each generation source that received FITs under the RES Act, the Commission obtained data on the total generation in 2009, and the total FIT payments in 2009. The data was sourced from the four electricity transmission system operators that are liable to pay FITs under the RES Act (EEG/KWK-G 2010a).

Electricity price data

The Commission made the assumption that the value of electricity displaced by renewables (p_0) is equal to the annual average wholesale price of electricity. The German Ingenieurbüro für neue Energien (IFNE) (2010) calculated the average wholesale market price of electricity based on electricity futures price data from the European Energy Exchange. It reported that the average price of electricity in 2009 was €68.80/MWh (A$99). This value was also used by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2010) in its assessment of the costs and benefits of renewable energy in Germany. It is worth noting that the wholesale electricity price reported by IFNE was significantly higher in 2009 than in either 2008 (€57.20/MWh (A$82)) or 2010 (€52.60/MWh (A$75)). The effect of a lower wholesale price is examined in the sensitivity analysis.

Identifying policy-induced generation

In order to estimate the subsidy equivalent, it is necessary to estimate the proportion of renewable energy that has been induced by the RES Act. German Governments have provided this type of incentive for generators of renewable energy since 1991, when the *Electricity Feed Act* (*Stromeinspeisungsgesetz*) was adopted. The RES Act entered into force in 2000, replacing the Electricity Feed Act. While there are other

policies that promote the use of renewables, the Commission has taken the view that the long-running national level FITs are the primary policy instrument for incentivising renewables, and that 100 per cent of renewable energy generated in Germany can be attributed to this policy.

Table F.3 **Calculations**

Germany, 2009

Variable	*Definition*	*Source*	*Unit*	*Value*
q_i	Annual generation of each subsidised source	Vivid Economics (unpublished data)	GWh	table F.4
FIT_i	Total value of FITs received by each type of generator	Vivid Economics (unpublished data)	€m	table F.4
p_i	Average tariff received by renewable generators	Calculation	€/MWh	FIT_i / q_i
p_0	Average wholesale price of electricity	Ingenieurbüro für neue Energien (2010)	€/MWh	68.80
□$_i$	Production subsidy equivalent (for each source)	Calculation	€/MWh	$p_i - p_0$
SE	Subsidy equivalent (for each source)	Calculation	€m	□$_i \cdot q_i$

Table F.4 **Subsidy equivalent estimates, Renewable Energy Sources Act**

Germany, 2009

Source	*qi*	*FITi*	*pi*	□*i*	*Subsidy equivalent*	
	GWh	€m	€/MWh	€/MWh	€m (2009)	A$m (2010)
Onshore wind	38 542	3 389	88	19	737	1 064
Biomass	22 980	3 700	161	92	2 119	3 058
Solar	6 578	3 157	480	411	2 704	3 902
Hydro	4 877	382	78	10	47	68
Landfill, sewage and mine gases	2 020	143	71	2	4	5
Offshore wind	38	5.6	150	81	3	4
Geothermal	19	3.7	198	130	2	4
Total	75 053	10 780		75	5 616	8 104

Sources: : EEG/KWK-G (2010a); German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2010); Ingenieurbüro für neue Energien (2010); RWI (2009); Productivity Commission estimates.

Estimating abatement

Each MWh of electricity that receives a subsidy under the RES Act displaces electricity from an alternative source. The displaced source will vary depending on the characteristics of the renewable generator.

The German Government's Federal Environment Office (Umweltbundesamt 2009) published estimates of the 'substitution factors' of a range of renewable energy sources. These represent estimates of how much electricity generated from coal, gas and oil is displaced for each MWh of renewable energy. For example, the substitution factors for solar power were reported as 50 per cent hard coal and 50 per cent natural gas. This means that for each MWh of electricity generated using solar power, half a MWh of hard coal-generated electricity and half a MWh of gas-fired electricity would be displaced.

The reported substitution factors were for 2007, and it is likely that there was some difference between the substitution factors in 2007 and 2009. But it is assumed that these would not be large enough to significantly affect estimates of abatement, and hence the Commission considers it a reasonable assumption that substitution factors from the German Federal Environment Office (Umweltbundesamt 2009) are valid for estimation of abatement in 2009.[1]

To estimate abatement requires data on the emissions intensity of the displaced source (table F.2). The average emissions intensity of each fuel source (unweighted) was used to estimate the emissions intensity of the displaced fuels.

For each energy source, the emissions intensity of the counterfactual fuel (a_o) is calculated as:

$$a_0 = \sum_{f=1}^{4} SubFac_f \bullet EI_f$$

where:

- the subscript f denotes the four fossil fuel types (lignite, hard coal, natural gas and oil)
- $SubFac_f$ is the substitution factor for each fuel (a percentage between 0 and 100)
- EI_f is the emissions intensity of the displaced fuel (in t CO_2/MWh).

1 It should be noted that the German Federal Environment Office stated that renewable energy sources do not displace nuclear energy at all.

The Commission made the assumption that the emissions intensity of each subsidised energy source (a_i) is zero. This assumption may not be entirely accurate for some mine gas. However, if the methane fraction of the mine gas would have escaped during the mining process, it is reasonable to assume that using it in electricity generation leads to much lower aggregate emissions than if the gas were vented without flaring (because methane has a 100 year global warming potential of 21 (UNFCCC nd)). Results are reported in table F.6.

Implicit abatement subsidy

The Commission's analysis suggests that in 2009 the RES Act provided subsidies for around 65 Mt of abatement. The estimated value of the subsidy equivalent was €5.6 billion (A$8.1 billion). This suggests that for the RES Act as a whole, the implicit abatement subsidy was around €95/t CO_2 (A$137). For some types of renewable energy, the subsidy was considerably higher (table F.5).

Table F.5 **Implicit abatement subsidy estimates, Renewable Energy Sources Act**

Germany, 2009

Units	*Hydro*	*Landfill, sewage and mine gas*	*Biomass*	*Geothermal*	*Onshore wind*	*Offshore wind*	*Solar*	*Average*
€/t CO_2 (2009)	12	2	116	154	24	102	599	96
A$/t CO_2 (2010)	17	3	167	223	35	147	864	137

Source: Productivity Commission estimates

Sensitivity analysis — wholesale electricity price

The Commission estimated the effect of using the 2010 wholesale electricity price (€52.60/MWh (A$75)) which was significantly lower than the 2009 price (€68.80/MWh (A$99)). The results (table F.7) show that a lower wholesale price of electricity implies higher values for the production subsidy equivalent, subsidy equivalent and implicit abatement subsidy.

Table F.6 **Abatement estimates, Renewable Energy Sources Act**

Germany, 2009

Variable	*Unit*	*Hydro*	*Landfill, sewage and mine gases*	*Biomass*	*Geothermal*	*Onshore wind*	*Offshore wind*	*Solar*	*Total*
q_i	GWh	4 877	2 020	22 980	19	38 542	38	6 578	75 053
Substitution factors									
Lignite	%	6	1	2	30	2	2	0	
Hard coal	%	69	66	73	45	72	72	50	
Natural gas	%	25	32	25	25	24	24	50	
Mineral oils	%	0	1	0	0	2	2	0	
Counterfactual emissions intensity									
Lignite	t CO_2/MWh	1.05							
Hard coal	t CO_2/MWh	0.90							
Natural gas	t CO_2/MWh	0.47							
Mineral oils	t CO_2/MWh	0.79							
Avoided emissions									
	t CO/MWh	0.80	0.76	0.80	0.84	0.80	0.80	0.69	
Abatement									
	Mt CO	3.9	1.5	18.3	0.0	30.8	0.0	4.5	59.1

Sources: Traber and Kemfert 2009; Umweltbundesamt 2009; Productivity Commission estimates.

Table F.7 **Sensitivity analysis, lower wholesale electricity price**
Germany, 2009

Source	q_i	*Market value of q_i*	*Production subsidy equivalent*	*Subsidy equivalent*		*Implicit abatement subsidy*	
	MWh	€m (2010)	€/MWh	€m (2010)	A$m (2010)	€/t CO_2	A$/t CO_2
Onshore wind	38 542	2 027	35.33	1 362	1 951	44	63
Biomass	22 980	1 209	108.41	2 491	3 569	136	195
Solar	6 578	346	427.24	2 811	4 027	622	891
Hydro	4 877	257	25.80	126	180	32	46
Landfill, sewage and mine gases	2 020	106	18.03	36	52	24	34
Offshore wind	38	2	97.27	4	5	122	175
Geothermal	19	1	145.80	3	4	174	249
Total	75 053	3 948	91.03	6 832	9 789	116	166

Sources: EEG/KWK-G (2010a); German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2010); Productivity Commission estimates.

F.4 Combined Heat and Power Act

Under the Combined Heat and Power Act (CHP Act), generators of combined heat and power receive payments for each kWh of electricity they feed into the grid. The payments are in addition to the wholesale price of electricity (not instead of, as is the case for RES Act FITs). The level of payments varies depending on the age of the plant, its size and its efficiency. In 2009, payments were between €0.0056/kWh and €0.0511/kWh (A$0.008–0.07).

Estimating the subsidy equivalent

Because the payments to generators under the CHP Act are in addition to the wholesale electricity price received, the value of the subsidy equivalent is equal to the total value of the payments in a given year, adjusted to account for the proportion of CHP that can be considered to have been induced by the Act.

Annual generation and total CHP Act payments

For each generation source that received payments under the CHP Act, the Commission obtained data on the total generation in 2009, and the total payments in

2009. The data was sourced from the four electricity transmission system operators that are liable to pay for CHP energy under the CHP Act (EEG/KWK-G 2010b). These data suggest that the total outlay under the CHP Act in 2009 was approximately €486 million (A$701 million).

Identifying policy-induced generation

In order to estimate the subsidy equivalent, it is necessary to estimate the proportion of CHP that has been induced by the CHP Act.

The CHP Act was introduced in 2002, and amended in 2008. The Commission considers that only plants that have been built or modernised since 2002 can be considered to have been induced by the CHP Act. According to the data on CHP Act payments and generation, new plants (built after 2002) accounted for approximately 30 per cent of total generation receiving CHP Act payments, and 57 per cent of total payments. This implies that the subsidy equivalent of the CHP Act was around €279 million (A$400 million) (table F.8). The Commission considers 30 per cent of total CHP generation to be an upper bound of the generation that can be considered to have been induced by the Act.

Table F.8 **Subsidy equivalent estimates, Combined Heat and Power Act**

Germany, 2009

Generator type	*Generation*	*Subsidy equivalent*
	GWh	€m (2009)
Modernised plants	13 612	218
Highly efficient, modernised plants	170	3
Small CHP plants >50kW, <2MW, that became operational after 1 April 2002 and before 31 December 2008	1 031	22
Small CHP plants <50kW	478	25
Highly efficient small CHP plants >50kW, <2MW, that became operational after 1 January 2009 and before 31 December 2016	187	5
Fuel cells	2	
Highly efficient new CHP plants >2MW	387	6
Total	15 867	279
Total (A$m 2010)		399

Source: EEG/KWK-G (2010b).

Estimating abatement

CHP plants produce electricity and heat that is fed into heat grids or used for other valued purposes. If this heat had not been generated through CHP, it would have been necessary to generate it through some other combustion process. Therefore, the abatement attributable to CHP depends on how much energy was saved that would otherwise have been used to generate heat, and the emissions intensity of the avoided combustion. The German Government (2007) published an analysis of CHP that the Commission has used to derive estimates of these values. Specifically, the German Government (2007):

- estimated that in 2003, CHP in Germany produced 58.4 TWh of electricity and 155 TWh of heat. This implies that for each TWh of electricity produced by CHP, approximately 2.65 TWh of heat is also produced (=155/58.4) (derived from p. 10)
- assumed that for each TWh of heat produced by CHP, there would be a saving of 0.71 TWh of primary energy (derived from p. 21)
- assumed that for each TWh of primary energy saved through CHP, there would be a saving of 0.31 Mt CO_2 (derived from p. 21).

Based on these estimates, the CHP Act can be credited with abatement of approximately 9 Mt CO_2 in 2009 (table F.9).

Table F.9 **Abatement estimates, Combined Heat and Power Act**
Germany, 2009

Variable	*Units*	*Value*	*Calculation*
Total induced cogeneration electricity production (2009) (q_i)	TWh	15.87	
Electricity to heat conversion factor (2003) (β)	TWh thermal energy per TWh electrical energy	2.65	
Estimated cogeneration heat production (2009) (q_h)	TWh	42.12	$q_h = q_i\beta$
Primary energy saving factor (α)	TWh primary energy per TWh thermal energy	0.71	
Estimated primary energy saving (q_e)	TWh	29.84	$q_e = q_h\alpha$
CO_2 saving factor (θ)	Mt CO_2 per TWh primary energy saved	0.31	
Estimated CO_2 saving (Ai)	Mt CO_2	9.14	$A_i = q_e\theta$

Sources: EEG/KWK-G (2010b); German Government (2007); Productivity Commission estimates.

Implicit abatement subsidy

The estimates of the subsidy equivalent of the CHP Act (€279 million (A$399 million)) and the abatement attributable to the Act (9 Mt CO_2) imply that the implicit abatement subsidy delivered by the policy is around €30/t CO_2 (A$44).

Sensitivity analysis

The estimate of the subsidy equivalent is based on primary source data on CHP payments, and is considered reliable. The estimated abatement is based on a number of assumptions. Varying any of these assumptions would be expected to affect the abatement estimate, and the estimate of the implicit abatement subsidy. The Commission has performed the following sensitivity analysis:

- It is possible that since 2003, electricity generation used for CHP has become more efficient, meaning that for each unit of electricity, less waste heat is produced. This is represented by reducing β by 20 per cent (from 2.65 to 2.12).
- It is possible that heat generation has also become more efficient than was estimated for 2003 by the German Government (2007). This is represented by reducing α by 10 per cent (from 0.71 to 0.64).
- It is possible that fuel combustion has become less emissions intensive (for example, through a switch from coal to gas, or through improved combustion technologies). This is represented by increasing θ by 10 per cent.

The results of the analysis suggest that the implicit abatement subsidy of the CHP Act is between €28 and €38/t CO_2 (A$40 and A$55) (table F.10).

Table F.10 **Sensitivity analysis, Combined Heat and Power Act**
Germany, 2009

Sensitivity scenario	*'Central' case*	*More efficient electricity generation*	*More efficient heat generation*	*Less emissions-intensive combustion*
Parameter change	None	β ↓ 20 % (to 2.12)	α ↓ 10 % (to 0.64)	θ ↑ 10 % (to 0.34)
Estimated abatement (Mt CO_2)	9.1	7.3	8.2	10.1
Implicit abatement subsidy				
€/t CO_2 (2009)	30	38	34	28
A$/t CO_2 (2010)	44	55	49	40

Sources: EEG/KWK-G (2010b); German Government (2007); Productivity Commission estimates.

F.5 European Union Emissions Trading Scheme

The Commission's analysis of the effects of the European Union ETS on Germany's electricity generation sector follows the same approach as was taken for the European Union ETS in the United Kingdom (appendix J). That is, the Commission has attempted to investigate the extent to which the European Union ETS has led to fuel switching from coal to gas. The mechanism that drives the coal–gas switch is the effect of the European Union ETS price on the marginal costs of each type of generator.

Based on data on European Union Allowance (EUA) prices and the average emissions intensity of coal and gas-fired generators, the Commission has estimated that on average, the European Union ETS increased the marginal costs of coal-fired generators in Germany by €12.81/MWh (A$18.35), and gas-fired generators by €6.74/MWh (A$9.66) (table F.11). This implies that the implicit production subsidy to gas under the European Union ETS is €6.07/MWh (A$8.70).

Table F.11 **Parameter values, European Union ETS**
Germany, 2010

Parameter	*Notation*	*Value*	*Source*
Emissions intensity (t CO_2/MWh)			
Coal (black)	a_c	0.90	Traber and Kemfert (2009)
Gas	a_g	0.47	Traber and Kemfert (2009)
Average EUA price (2010)	p_{EUA}	€14.23 (A$20.39)	Vivid Economics (unpublished data)
Average wholesale price of electricity (2010) (€/MWh)	p_1	€52.60	Vivid Economics (unpublished data)
Total generation (2010) (TWh)			
Coal (black)	q_c	116	
Gas	q_g	86	
Marginal cost increases			
Coal	c_c	€12.81	$c_c = a_c \cdot p_{EUA}$ = €12.81
Gas	c_g	€6.74	$c_g = a_g \cdot p_{EUA}$ = €6.74

Sources: Ellerman and Feilhauer (2008); Frontier Economics (unpublished data); Traber and Kemfert (2009); Vivid Economics (unpublished data); Productivity Commission estimates.

Switching from coal to gas

Ellerman and Feilhauer (2008) estimated that in 2005 fuel switching led to an increase of between 2 and 12 per cent in the use of gas for electricity generation. This is less fuel switching than was estimated to occur in the United Kingdom (McGuiness and Ellerman (2008) estimated that the comparable figures for the United Kingdom were between 19 and 24 per cent). One explanation for this is that Germany has less gas-fired capacity than the United Kingdom (and hence fewer opportunities for fuel switching in the short term, because the surplus gas-fired capacity is likely to be less than in the United Kingdom):

- In 2009, natural gas constituted around 15 per cent of total electricity generation capacity in Germany (Frontier Economics (unpublished data)). In the United Kingdom, the comparable figure for 2009-10 was around 41 per cent (Frontier Economics (unpublished data)). The differences in capacity are reflected in generation. For example, in 2010, natural gas accounted for around 13 per cent of total electricity generation in Germany, compared to around 44 per cent in the United Kingdom.
- Delarue, Ellerman, and D'haeseleer (2008, p. 35) state that around half of Germany's gas-fired generation is CHP 'and therefore typically not part of the gas-fired capacity that can be readily switched when the economic incentives are right'.
- Over time, the ETS would be expected to provide an incentive for further investment in gas-fired capacity, and hence greater opportunities for fuel switching in the future.

As was noted in the section on the effects of the European Union ETS in the United Kingdom (appendix J), the price of EUAs was significantly higher in 2010 than in 2005-06 (€14.23 compared to €23). Based on this, the Commission considers that it is unlikely that the European Union ETS has led to an increase in natural gas use in Germany of more than 12 per cent. The Commission's 'central' estimate of abatement was based on the assumption that the European Union ETS led to an increase of 7 per cent in the use of gas in 2010, relative to a counterfactual of no ETS. Values of 2 per cent and 12 per cent are used for sensitivity analysis.

To estimate the abatement attributable to fuel switching, the Commission has assumed that gas displaces black (hard) coal. This is based on an analysis of the existing literature:

- Sijm et al. (2008) state that the marginal generator in Germany is usually coal (both peak and off-peak).

- The indicative merit order curve provided by Frontier Economics (unpublished data) suggests that black coal and gas are likely to be the marginal generator.
- Vivid Economics (2011) quotes two sources that suggest that the marginal generator in Germany is likely to be either black coal or gas.

Germany does have some brown coal capacity, but the marginal costs of brown coal are so much lower than black coal that it is unlikely that gas is currently displacing brown coal. The rate of abatement from black coal–gas switching is given by:

$a_c - a_g = 0.90 - 0.47 = 0.43$ t CO_2/MWh.

Using data on the actual production of gas-fired electricity in 2010, it is possible to estimate the total amount of gas-fired generation that was induced by the European Union ETS (5.6 TWh) and the abatement attributable to the fuel switch (2.4 Mt CO_2) (table F.12).

The subsidy equivalent is equal to the implicit production subsidy to gas-fired generation (€6.07/MWh) multiplied by the total increase in gas-fired generation, and was estimated to be €34 million (A$49 million).

The implicit abatement subsidy is the subsidy equivalent divided by abatement attributable to the ETS, and is equal to the EUA price — €14.23/t CO_2 in the year of analysis (A$20.39).

Table F.12 **European Union ETS-induced gas generation, abatement and subsidy equivalent**[a]

Germany, 2010

Value	*Calculation*	*Estimate*
Total gas generation 2010	g	86 TWh
Total gas generation induced by the ETS	$q_g = g - (g / 1.07)$	5.6 TWh
Subsidy equivalent[b]	$SE = q_g \cdot 10^6 \cdot €6.07$	€34 million (A$49 million)
Abatement	$A = q_g \cdot (a_c - a_g)$	2.4 Mt CO_2
Implicit abatement subsidy	p_{EUA}	€14.23

[a] Assuming that the European Union ETS led to an increase of 7 per cent in the use of gas in 2010, and gas displaced black coal. [b] The quantity of gas induced by the ETS is multiplied by 10^6 because generation is in TWh and the production subsidy equivalent is in €/MWh.

Source: Productivity Commission estimates.

Sensitivity analysis

The Commission analysed the effects of varying the assumption about the amount of gas-fired generation that was induced by the European Union ETS, using parameter values of 2 and 12 per cent (table F.13). This affects the subsidy equivalent and abatement estimates, but does not alter the estimate of the implicit abatement subsidy, which is the EUA price (€14.23/t CO_2 ($20.39)).

Table F.13 **Sensitivity analysis, ETS induced gas generation**
Germany, 2010

Increase in natural gas generation attributable to the ETS	*Induced generation*	*Subsidy equivalent*		*Abatement*
%	TWh	€m (2010)	A$m (2010)	Mt CO_2
2	1.7	10	15	0.7
7 ('central' case)	5.6	34	49	2.4
12	9.2	56	80	3.9

Source: Productivity Commission estimates.

The interaction of the European Union ETS with other policies

Subsidy equivalent

As noted in section J.7, in the United Kingdom the European Union ETS delivers a benefit to renewables and CHP by increasing the average wholesale price of electricity. The same effect holds for CHP in Germany, but there is a different effect on renewables, because the German system of subsidies for renewables is based on FITs rather than renewable energy certificates.

Under the CHP Act, CHP generators receive payments for each kWh of electricity fed into the grid. The payments are in addition to the wholesale price of electricity. The European Union ETS does not change the value of the production subsidy under the CHP Act. However, the increase in the wholesale price of electricity increases the revenue to CHP, leading to a higher subsidy equivalent.

The Commission estimated a proxy for the wholesale price uplift based on the assumption that gas is the marginal generator 10 per cent of the time, and black coal 90 per cent of the time. (The estimate was based on 2009 data and an average EUA price of €13.50.) This implies that the average emissions intensity of the marginal generator over the course of the year is 0.95 t CO_2/MWh.

Using this estimate implies that the European Union ETS led to an increase in wholesale electricity prices of (€13.50*0.95 = €12.78/MWh (A$18.31)). (This compares to an average 2009 wholesale electricity price of €68.80/MWh (A$121)).

CHP generators face an increase in their marginal costs because they emit CO_2. The marginal cost uplift is equal to the EUA price multiplied by the average emissions intensity of generation. Frontier Economics (unpublished data) estimated that the average emissions intensity of CHP in 2008 was 0.5 t CO_2/MWh. Hence, the net production subsidy equivalent to CHP was €6.03/MWh (= (€12.78 – (€13.50 x 0.50))). This net subsidy was received by the 15.9 TWh of electricity that was estimated to have been induced by the CHP Act. This implies that the additional subsidy equivalent to CHP was around €95 million (A$136 million).

Under the RES Act, renewable generators receive a FIT instead of receiving the wholesale electricity price. If the European Union ETS did not exist, the counterfactual (wholesale) price renewable generators would have received for their electricity would be lower, and the production subsidy equivalent (the difference between the FIT and the wholesale price) would have been larger. Hence, the European Union ETS effectively reduces the subsidy equivalent to renewables that receive FITs. Using the same assumptions as were used for CHP implies that if Germany was not a part of the European Union ETS, renewables generators would have received an additional subsidy equivalent of around €953 million (A$1.4 billion) (2009 value converted to A$ (2010)).

Abatement

Both the RES Act and the CHP Act operate within the bounds of the European Union ETS. The European Union ETS sets a binding cap on total greenhouse gas emissions from selected sectors within the European Union, including electricity generation. Because total emissions are capped, complementary measures (including support for renewable energy and CHP in particular countries) can not lead to any additional abatement across the European Union as a whole. While emissions from electricity generation in Germany might fall, emissions would rise in other sectors and other countries, so the policy would have no net effect.

Traber and Kemfert (2009) constructed a model of the European electricity market to estimate the effects of Germany's FITs on electricity-sector greenhouse gas emissions in Germany and the European Union as a whole. Their model is based on 2006 data, and makes a number of assumptions about the behaviour of electricity generators and the operation of electricity markets. Two key findings of their paper were that the FITs lead to a 'substitution effect' and a 'permit price effect'.

The ‘substitution effect’ refers to the incentive that the FITs create for Germany’s electricity network operators to substitute away from conventional energy sources toward renewable energy. Traber and Kemfert estimated that in Germany the substitution effect would reduce electricity-derived greenhouse gas emissions by approximately 16 per cent. There would also be some minor effects on emissions from neighbouring countries that purchase electricity from Germany, including the Czech Republic (1 per cent reduction in emissions), Denmark (2 per cent) and the Netherlands (2 per cent). Across the European Union as a whole, Traber and Kemfert estimated that the substitution effect would reduce emissions by 4.5 per cent.

However, the substitution toward renewable energy is almost totally offset by the ‘permit price effect’. Germany’s support for renewable energy effectively reduces the emissions reduction burden that must be borne by the rest of the European Union. This leads to lower permit prices — Traber and Kemfert estimated that the RES Act would reduce permit prices by 15 per cent (from €23 to €20). In turn, this leads to less abatement outside Germany’s electricity sector. In particular, emissions are likely to rise from ‘firms that are only loosely connected with the German grid and have high emissions’ (Traber and Kemfert 2009, p. 175). This is likely to include emissions-intensive electricity generators in Spain and Italy (RWI 2009). Traber and Kemfert estimated that the permit price effect would increase electricity-derived greenhouse gas emissions across the European Union by 3.9 per cent.

Taken in aggregate, the substitution effect and the permit price effect were estimated to lead to a net reduction in European Union electricity-derived greenhouse gas emissions of 0.5 per cent. Presumably, unless emissions reduction caps were tightened, even this modest abatement would be offset by higher emissions from non-electricity sectors that are subject to the European Union ETS.

The net effect of the substitution effect and the permit price effect could be described as ‘intra-Europe carbon leakage’. German consumers and firms incur additional costs for emissions reduction through the RES and CHP Acts, with the effects on emissions being entirely offset by other countries that do not impose the same burden on their economies.

F.6 Summary

Based on the subsidy equivalent and abatement estimates for each policy outlined in the sections above, estimates for Germany’s electricity generation sector total

subsidy equivalent, total abatement and the average implicit abatement subsidy can be estimated.

The total subsidy equivalent

The Commission's estimate of the total subsidy equivalent for Germany's electricity generation sector is based on a counterfactual of the wholesale electricity price in the absence of the European Union ETS. Hence, the total subsidy equivalent is the sum of the subsidy equivalents estimated for:

- the RES Act
- the CHP Act
- the European Union ETS subsidy equivalents for gas, renewables and CHP.

The Commission estimated the total subsidy equivalent for Germany's electricity sector at between €7 billion and €8 billion (A$10 billion and A$12 billion) (table F.14). This represents between 0.28 and 0.33 per cent of Germany's GDP.

Table F.14 **Electricity sector total subsidy equivalent[a]**
Germany, 2010

Policy	*'Central'*	*Low*	*High*	*'Central'*	*Low*	*High*
	€m (2010)	€m (2010)	€m (2010)	A$m (2010)	A$m (2010)	A$m (2010)
Renewable Energy Sources Act	5 656	5 656	6 832	8 104	8 104	9 789
Combined Heat and Power Act	279	279	279	399	399	399
European Union ETS						
• Coal/gas switch	34	10	56	49	15	80
• Subsidy to renewables	953	953	953	1 365	1 365	1 365
• Subsidy to CHP	95	95	95	136	136	136
Total	7 017	6 993	8 214	10 053	10 019	11 769

a High — the highest subsidy equivalent estimated under sensitivity analysis. Low — the lowest subsidy equivalent estimated under sensitivity analysis. No sensitivity analysis was carried out for the estimates of the effects of the European Union ETS on the policies to encourage the use of renewables.

Source: Productivity Commission estimates.

Total abatement

The Commission has estimated the abatement that arises from three sources:

- the switch from coal to gas attributable to the European Union ETS
- the increased use of renewables due to the combined effects of the European Union ETS and the RES Act

- the increased use of CHP due to the combined effects of the European Union ETS and the CHP Act.

The Commission has estimated that these policies have delivered abatement of between 67 and 73 Mt CO_2 in Germany's electricity generation sector (compared with total electricity sector emissions of around 300 Mt in 2009) (table F.15). This represents between 18 and 20 per cent of Germany's counterfactual emissions from electricity in 2009. It should be noted that Germany's participation in the European Union ETS means that any abatement in Germany's electricity generation that arises from the RES Act or the CHP Act is likely to be offset by higher emissions elsewhere in the European Union.

Table F.15 **Electricity sector total abatement[a]**
Germany, 2010

Source of abatement	*'Central'*	*Low*	*High*
	Mt CO_2	Mt CO_2	Mt CO_2
Renewables	59.1	59.1	59.1
Combined heat and power	9.1	7.3	10.1
European Union ETS-induced coal–gas switch	2.4	0.7	3.9
Total	70.6	67.1	73.1

a High — the highest abatement estimated under sensitivity analysis. Low — the lowest abatement estimated under sensitivity analysis.

Source: Productivity Commission estimates.

Average implicit abatement subsidies

The Commission has estimated the implicit abatement subsidies for each of the policies analysed (table F.16) and for Germany's electricity sector as a whole (table F.17). The estimated average implicit abatement subsidy was between €95 and €124/t CO_2 ($137 and $178/t CO_2). The reason that the average implicit abatement subsidy for the electricity generation sector as a whole can exceed the highest estimated implicit abatement subsidy for any of the three policies individually is that all of the abatement from renewable energy has been attributed to the RES Act, and all the abatement from CHP to the CHP Act. However, these energy sources also receive effective subsidies as a result of the European Union ETS. These additional subsidies are included in estimates of the implicit abatement subsidies, increasing the total subsidy equivalent, without adding any additional abatement to the totals. This has the effect of increasing the average implicit abatement subsidies.

Table F.16 **Implicit abatement subsidies[a]**

Germany, 2009, 2010

Policy	'Central'	Low	High	'Central'	Low	High
	€/t CO_2 (2010)	€/t CO_2 (2010)	€/t CO_2 (2010)	A$/t CO_2 (2010)	A$/t CO_2 (2010)	A$/t CO_2 (2010)
RES Act	96	96	116	137	137	166
CHP Act	30	28	38	44	40	55
European Union ETS (coal–gas switch)	14	0	14	20	0	20

a High — the highest implicit abatement subsidy estimated under sensitivity analysis. Low — the lowest implicit abatement subsidy estimated under sensitivity analysis.

Source: Productivity Commission estimates.

Table F.17 **Electricity generation sector average implicit abatement subsidies[a]**

Germany, 2009, 2010

	Implicit abatement subsidy					
Subsidy equivalent scenario	*'Central abatement'*	*High abatement*	*Low abatement*	*'Central' abatement*	*High abatement*	*Low abatement*
	€/t CO_2 (2010)	€/t CO_2 (2010)	€/t CO_2 (2010)	A$/t CO_2 (2010)	A$/t CO_2 (2010)	A$/t CO_2 (2010)
'Central'	99	96	104	142	138	150
High	118	114	124	169	164	178
Low	99	95	104	141	137	149

a High — the highest subsidy equivalent estimated under sensitivity analysis. Low — the lowest subsidy equivalent estimated under sensitivity analysis.

Source: Productivity Commission estimates.

F.7 Other electricity generation policies in Germany

Excluded policies

The three policies that were analysed cover the majority of the subsidised abatement in Germany's electricity generation sector. However, there are several other policies that the Commission did not include in its analysis due to time and data constraints, or because they were not thought likely to be leading to material levels of abatement or imposing material resource costs.

Germany's electricity tax was not included in the analysis because generally it is not differentiated based on the source of the electricity. Some electricity from renewables is exempt, however renewable energy fed into the normal transmission

grid is taxed the same as non-renewable energy. It is likely that most renewable energy is subject to the tax, and that it does not provide a material subsidy for renewable energy in most circumstances.

As well as production subsides for CHP, the CHP Act also provides capital subsidies for the builders of networks for the transmission of heat. These projects could provide a further incentive for the use of CHP. If this policy were included in the analysis, the total subsidy equivalent and average implicit abatement subsidy estimates for Germany would be expected to rise. The estimate of abatement would not be expected to change, because the effects of CHP have largely been captured through the production subsidies to CHP.

There are numerous policies at the state (Länder) level that provide capital subsides or 'soft' loans for renewable generation technologies. The Commission was not able to access data on these programs. Including them in the analysis would be expected to increase the total subsidy equivalent and average implicit abatement subsidy estimates, but would probably not have a material effect on the estimate of abatement because the subsidised renewables probably receive FITs.

Committed policies

As a member of the European Union, Germany is committed to the European Union's 20-20-20 targets to be achieved by 2020:

- A reduction in European Union greenhouse gas emissions of at least 20 per cent, compared to 1990 levels.
- 20 per cent of European Union energy consumption to come from renewable resources (each country has individual targets to contribute to this goal).
- Energy efficiency measures to reduce primary energy use by 20 per cent compared with projections.

One policy that could have material effects on Germany's electricity generation mix and emissions is the nuclear phase-out. Under current policies, Germany's nuclear reactors are to be progressively shut down over time. However, the damage to the Fukushima nuclear reactor in Japan in March 2011 led the German Government to temporarily shut down eight nuclear reactors. At the time of writing, it was not clear when the plants would reopen, and whether there would be additional restrictions on nuclear power. This has added to the uncertainty about the future of nuclear power in Germany.

G Japan's electricity generation sector

The Commission estimated the impact of seven Japanese policies — the Japanese Renewable Portfolio Standard (RPS), the Project for Promoting the Local Introduction of New Energy, the Project for Supporting New Energy Operators, the New Buyback Program for Solar Photovoltaic (PV), the National PV Capital Subsidies, the Tokyo PV Capital Subsidies and the Petroleum and Coal Tax.

A number of other policies were considered, but were not included in the analysis as they were deemed unlikely to affect the aggregate results in a material way, or because data limitations prevented their estimation. In addition, the Commission was unable to locate data on the full subsidies provided by the Project for Promoting the Local Introduction of New Energy and the Project for Supporting New Energy Operators. As such, only the wind components of these schemes have been estimated, and therefore the total subsidy equivalent and total abatement estimates for Japan may be an underestimate.

The policies have been estimated for the Japanese 2009 fiscal year (1 April 2009 to 31 March 2010, hereafter referred to as FY 2009). The estimates have been converted to Australian currency using the average exchange rate over this period (A$0.0126/¥).

G.1 Electricity generation in Japan

The Japanese electricity sector

The electricity sector in Japan is largely operated by ten privately-owned vertically-integrated utilities (VIUs), each operating in a distinct region (table G.1). These utilities operate the transmission networks, are responsible for balancing supply and demand in their region, and operate much of the generation capacity. Historically, interconnections between the VIU regions have been limited (IEA 2008). In particular, there is limited connection between the Western side of the grid and the Eastern side of the grid.

Table G.1 **VIU regions**
Japan, 2008

VIU region	*Capacity as of 2008*	*VIU region*	*Capacity as of 2008*
	GW		GW
Tokyo	78	Shikoku	14
Kansai	44	Hokkaido	9
Kyushu	30	Hokuriku	9
Tohuku	27	Chubu	40
Chugoku	22	Okinawa	2

Source: IEA (2008).

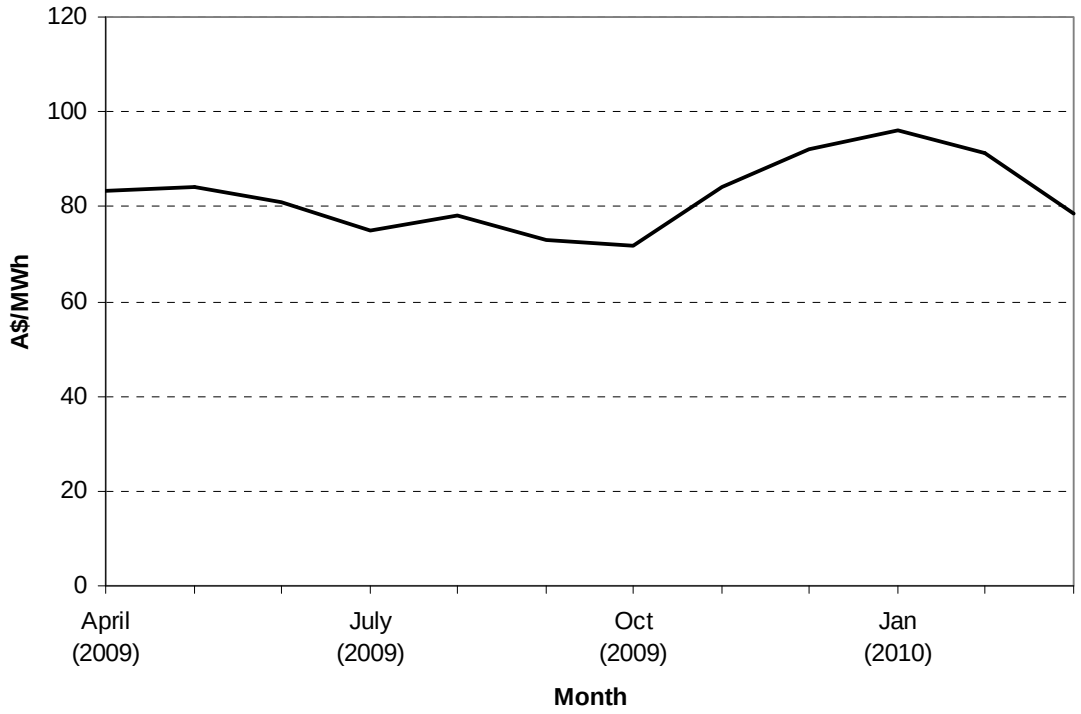
A limited portion of the market has been deregulated. High voltage customers with demand above 50 kW are able to choose their own supplier. Others must use the VIUs as suppliers. According to the International Energy Agency (IEA 2008), in FY2006, customers representing 1.3 per cent of load chose a non-VIU supplier, and 11 per cent of the load was via autoproducers (those supplying their own generation). A small power exchange (the Japanese Electric Power Exchange) also operates, however, trading on this market is limited (in FY 2009, a total of 3.5 TWh of generation was traded on the exchange — about 0.3 per cent of total generation (JEPX 2010)).

Key statistics

Wholesale electricity price

The only available data on wholesale prices were from the Japanese Electric Power Exchange (which, as noted above, forms a very small part of the market). In FY 2009, the unweighted monthly average price on this exchange ranged from around ¥5982/MWh (A$70/MWh) to ¥7687/MWh (A$96/MWh), with an average price of ¥6528/MWh (A$82/MWh). The Commission did not require estimates of the wholesale electricity price for the analysis of Japan's electricity sector measures but has included the data here for illustrative purposes (figure G.1).

Figure G.1 **Japanese Electric Power Exchange wholesale prices**
Japan, April 2009 – March 2010

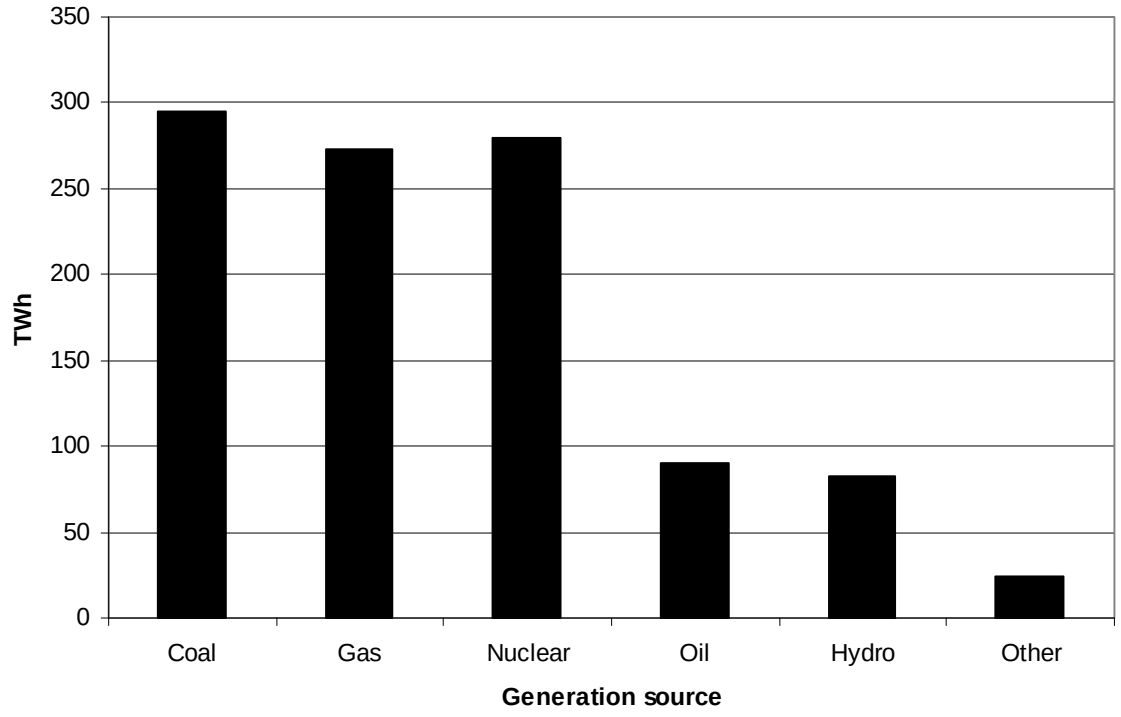


Source: JEPX (2010).

Fuel used in electricity generation

In 2009, total electricity generation was 1046 TWh. Japan's electricity generation sector consists of relatively equal proportions of coal, gas and nuclear based generation (each generated approximately 26–28 per cent of Japan's electricity in 2009) (figure G.2). Oil and hydro also generate a significant proportion of Japan's electricity (approximately 8–9 per cent each in 2009).

Figure G.2 **Generation sources used in Japan's electricity sector**[a]
Japan, 2009



a 'Other' includes mostly renewable sources.

Source: IEA (2010e).

Aside from hydro, biomass and waste are the largest sources of renewable energy generation in Japan (table G.2). Japan also has smaller amounts of wind, geothermal and solar electricity.

Table G.2 **Renewable generation**
Japan, 2009

Source	*Generation*	*Proportion of total generation*
	TWh	%
Hydro	82.6	7.9
Biomass and Waste	16.3	1.6
Wind	3.4	0.3
Geothermal	2.9	0.3
Solar	2.3	0.2

Source: IEA (2010e).

Emissions

In 2008, total emissions from the Japanese electricity and heat sectors was 396 Mt CO_2 (UNFCCC 2011) (of which electricity is likely to make up a large proportion). The average emissions intensity of the Japanese electricity and heat sector was 0.436 t CO_2/MWh in 2008 (table G.3).

Table G.3 **Emissions intensity of electricity and heat generation[a]**
Japan, 2008

Source	*Emissions intensity*
	t CO_2/MWh
Coal	0.911
Gas	0.439
Oil	0.574
Grid average	0.436

a Note that heat makes up a small proportion of these figures, and as such they are largely reflective of the emissions intensity of electricity generation.

Source: IEA (2010a).

G.2 Abatement

In order to calculate the abatement 'induced' by each policy, an estimate of the generation source that was replaced by the low-emissions generation was required. This was based on an assessment of the marginal generator — the highest cost generation in the merit order — which is the most likely generator to be replaced by renewable electricity. Note that this would be a reasonable assumption if the VIUs were profit maximising.

According to the Federation of Electric Power Companies of Japan (FEPC 2010), oil and pumped-storage generation were used to meet peak load fluctuations in demand in Japan. The emissions intensity of pumped storage generation is equal to the emissions intensity of the generator used to pump the water, plus some efficiency loss. The Commission was not able to obtain information on the emissions intensity of pumped-storage generation and for this reason did not included it in its estimates of the emissions intensity of the marginal generator. Instead, the Commission assumed that oil was the marginal generator. This is supported by IEA analysis of the costs of oil-fired generation. The IEA stated that 'oil-fired capacity [in Japan] is relatively old and depreciated — as well as expensive to operate' (IEA 2008, p. 121).

The average emissions intensity of oil-fired generation in Japan in 2008 was 0.574 t CO_2/MWh (table G.3). This was the counterfactual emissions intensity used to estimate abatement in the Commission's 'central' analysis.

The Commission has also considered an alternative counterfactual — gas-fired generation. The Federation of Electric Power Companies of Japan (FEPC 2010) suggested that in the Japanese merit order, gas-fired generation was dispatched before oil. In periods of low demand, it is possible that there would be no oil-fired generation, and thus the marginal generator would be gas. This counterfactual could thus be considered a lower bound on the marginal emissions intensity. The alternative emissions intensity used was 0.439 t CO_2/MWh.

G.3 Policy overlaps

The Commission has estimated the subsidy equivalent and abatement attributable to seven policies: the Japanese RPS, the Project for Promoting the Local Introduction of New Energy, the Project for Supporting New Energy Operators, National Solar PV Feed-in Tariffs, National PV Capital Subsidies, Tokyo PV Capital Subsidies and the Petroleum and Coal Tax. There are considerable overlaps between the policies that have led the Commission to presume that:

- the abatement covered under the RPS was not considered to overlap with the PV subsidies at all. The PV subsidies apply only to residential solar, whereas solar within the RPS does not contain generation which is used for 'self-use'. In addition, generation receiving the feed-in tariffs cannot receive credit under the RPS
- wind subsidies received through the Project for Promoting the Local Introduction of New Energy and the Project for Supporting New Energy Operators are assumed to fully overlap with the RPS, where the subsidies were granted after the RPS commenced
- PV systems subsidised through the Tokyo PV Capital Subsidies are also subsidised through the National PV Capital Subsidies (100 per cent overlap)
- the New Buyback Program for Solar PV (national FITs) was estimated to overlap by 90 per cent with the National PV Capital Subsidies. (Both policies apply to residential solar PV, but the national FITs also subsidise some non-residential installations. The Commission has estimated that non-residential installations account for 10 per cent of total subsidies under the FITs.)
- the Petroleum and Coal Tax was considered to provide an effective production subsidy to all renewables, but not lead to any additional abatement that was not captured by the other policies.

Taking into account these overlaps, the total abatement attributable to these policies was estimated to arise from:

- electricity generation that was induced by the RPS
- electricity generation subsidised under the Project for Promoting the Local Introduction of New Energy and the Project for Supporting New Energy Operators prior to the commencement of the RPS
- electricity generation that was subsidised under the National PV Capital Subsidies
- 10 per cent of the electricity generation that was subsidised through the National FITs.

Other policies provide additional support to electricity generation from renewables, but these subsidies are to a large extent estimated to overlap with other subsidies.

Due to the overlap between the policies, the Commission estimated the abatement, and thus the implicit abatement subsidy, for two groups of policies:

- the RPS, the Project for Supporting the Local Introduction of New Energy, and the Project for Supporting New Energy Operators (section G.4)
- the National PV Capital Subsidies, the Tokyo PV Capital Subsidies and the Buyback Program (section G.5).

Thus the estimates take into account these policy interaction effects.

G.4 Renewable Portfolio Standard and wind subsidies

Due to overlaps between the policies, the Commission estimated the abatement, and hence the implicit abatement subsidy, for three programs combined — the RPS, the Project for Promoting the Local Introduction of New Energy, and the Project for Supporting New Energy Operators. The subsidy equivalent for each policy was estimated separately.

Renewable Portfolio Standard

The Japanese RPS was introduced in 2003, and requires VIUs to source a specified percentage of their electricity sales from eligible renewable sources. (Note that large hydro and most geothermal are not eligible. In addition, electricity generated for 'self-use' is not covered.) The 2010 target was for 10 TWh of renewable electricity.

Retailers can meet their obligations in several ways:

- by generating the electricity themselves
- by purchasing the electricity from another retailer
- by purchasing renewable electricity certificates.

Unlike many similar schemes, such as Australia's Renewable Energy Target, the bulk of the obligation appears to be met by self-generation — only a small proportion of certificates are traded. According to the Institute of Energy Economics, Japan (IEEJ) (pers. comm., 8 April 2011), only 233 GWh of renewable certificates were issued in FY 2009, out of 8.61 TWh of eligible renewable generation.

The scheme includes a banking mechanism, which has led to an oversupply of permits. This was due to low targets and a large amount of eligible pre-existing generation in the early years of the scheme, which resulted in a substantial amount of banking. This meant that renewable generation in FY 2009 was less than required by the target in FY 2009 — the difference was made up by banked permits.

However, due to this banking mechanism, the renewable energy permits have a non-zero price. Thus, despite the target being exceeded in previous years, there will still be a subsidy equivalent and abatement occurring due to the scheme.

Estimating the subsidy equivalent

The subsidy equivalent for the RPS was estimated by multiplying the 'induced' RPS eligible generation by the renewable certificate price.

In FY 2009, there was 8.61 TWh of eligible renewable generation in Japan. This consisted of:

- 3.7 TWh of wind
- 3.2 TWh of biomass
- 1 TWh of small hydro
- 0.7 TWh of solar (note that solar electricity was 'double counted' for the purposes of the RPS (IEA 2010i). This implies that 0.35 TWh of eligible solar was generated in FY 2009)
- minimal amounts of 'mixed power' and geothermal (METI and ANRE (Japan) 2010).

However, much of this generation may have already existed prior to the commencement of the scheme. While pre-existing generation receives credit under the scheme, in FY2003, when the scheme commenced, the target was adjusted down to represent the amount of renewable generation in FY2002 (this adjustment has since been removed). The adjustment factor was 4 TWh (METI (Japan) 2011a), and this was taken to be the amount of eligible renewable generation that occurred in FY2002. Therefore, 4.6 TWh of renewable generation was assumed to have been 'induced' by the scheme.

While, as noted above, most generation does not create certificates, the certificate price represents the effective subsidy given to renewable generation. Profit maximising VIUs will generate electricity up until the point where the cost of generation is equal to the electricity price plus the certificate price. Where the costs of generation exceed this value, retailers purchase renewable certificates rather than generate the electricity themselves.

According to IEEJ (pers. comm., 8 April 2011), the average certificate price in FY 2009 was ¥5.2/kWh (A$0.07/kWh). This resulted in a subsidy equivalent estimate of ¥23.8 billion (A$300 million).

Project for Promoting the Local Introduction of New Energy

The Project for Promoting the Local Introduction of New Energy subsidised up to half the installation costs for local governments and non-profit organisations installing renewable energy. The scheme subsidised a variety of technologies, including PV, wind, small hydro, some geothermal, solar thermal heat and biomass (heat, electricity and fuel).

This scheme has since ceased operating. However as it was in operation during FY 2009, it was relevant to the Commission's analysis. The Commission was only able to obtain data on the subsidies offered to wind generators under this scheme.

Estimating the subsidy equivalent

From FY1997 (when the scheme commenced) through to FY 2009, the Project for Promoting the Local Introduction of New Energy offered ¥21.9 billion in subsidies to wind generators (in ¥2009) (A$277 million) (METI (Japan), pers. comm., 20 May 2011). Converted into an annualised subsidy equivalent using a discount rate of 7 per cent and an economic lifetime of 20 years, this was estimated to be ¥2.1 billion (A$26 million).

Alternatively, discount rates of 3 and 11 per cent can be used. These discount rates resulted in subsidy equivalent estimates of ¥1.5 billion (A$19 million) and ¥2.8 billion (A$35 million) respectively.

Estimating annual generation

Since FY1997, 236 MW of wind capacity has been subsidised under this scheme. However, generation built since FY2003 will overlap fully with the RPS. As such, only the 106 MW of capacity subsidised before FY2003 was included in the estimates of generation (METI (Japan), pers. comm., 20 May 2011).

The EIA (US) (2011i) states that, in 2008 Japan had 1.8 GW of wind capacity, and 2.5 TWh of wind generation. This led to an estimate of the capacity factor of wind in Japan of around 16 per cent. Therefore, the annual generation of the subsidised capacity was estimated to be 150 GWh.

Project for Supporting New Energy Operators

The Project for Supporting New Energy Operators provided either a subsidy or a debt guarantee for installation of new energy, including biomass heat and electricity, biofuels, small hydro, geothermal, wind and solar PV. Like the Project for Promoting the Local Introduction of New Energy, this scheme has ceased operating, but was in operation during FY 2009. Again, only data on the subsidies provided to wind generation were available.

Estimating the subsidy equivalent

Between FY1997 and FY 2009, this scheme provided ¥130 billion (A$16 million) of subsidies to wind generators (METI (Japan), pers. comm., 20 May 2011). Using a 7 per cent discount rate, and a 20 year economic lifetime of the assets, the subsidy equivalent was estimated to be ¥12 billion (A$155 million).

Alternatively, discount rates of 3 and 11 per cent can be used These resulted in subsidy equivalent estimates of ¥8.8 billion (A$110 million) and ¥16 billion (A$206 million) respectively.

Estimating annual generation

Since FY1997, this scheme has provided subsidies to 2.3 GW of wind generation. However, as generation subsidised after FY2003 will overlap fully with the RPS,

only generation subsidised prior to FY2003 was included in the estimates of generation and abatement. This was equal to 542 MW (METI (Japan), pers. comm., 20 May 2011).

Using a capacity factor of 16 per cent, annual generation from this capacity was estimated to be 770 GWh.

Estimating the combined abatement and implicit abatement subsidy

Combined values for the subsidy equivalent, abatement and the implicit abatement subsidy can be estimated based on the above estimates.

The subsidy equivalent was estimated by simply adding together the three policy subsidy equivalent estimates. This was estimated to be between ¥34 billion and ¥43 billion (A$429 million and A$541 million), with a 'central' estimate of ¥38 billion (A$481 million).

Abatement was estimated by adding together the individual policy generation estimates, and multiplying by a counterfactual emissions intensity. Annual generation induced by the three schemes combined was estimated to be 5.1 TWh.

Using a counterfactual emissions intensity of 0.574 t CO_2/MWh, annual abatement from the schemes was estimated to be 3 Mt CO_2. Alternatively, using a counterfactual emissions intensity of 0.439 t CO_2/MWh, abatement was estimated to be 2 Mt CO_2.

Based on this, the implicit abatement subsidy for the three schemes combined could be estimated. This was estimated to be between ¥11 500/t CO_2 and ¥18 964/t CO_2 (A$145 and A$239), with a 'central' estimate of ¥12 899/t CO_2 (A$163) (table G.4).

Table G.4 **Summary, Renewable Portfolio Standard and Wind subsidies**

Japan, April 2009 – March 2010 (in 2009 values)

Scenario	*Subsidy equivalent*		*Abatement*	*Implicit abatement subsidy*	
	¥b	A$m	Mt CO_2	¥/t CO_2	A$/t CO_2
Oil counterfactual					
7 per cent discount rate	38	481	3	12 899	163
11 per cent discount rate	43	541	3	14 504	183
3 per cent discount rate	34	429	3	11 500	145
Gas counterfactual					
7 per cent discount rate	38	481	2	16 866	213
11 per cent discount rate	43	541	2	18 964	239
3 per cent discount rate	34	429	2	15 037	190

Source: Productivity Commission estimates.

G.5 Japan's solar PV programs

The Commission estimated the subsidy equivalents for three measures relating to solar PV in Japan — one federal level FIT (the Buyback program) and two capital subsidy programs. For abatement, the Commission estimated the combined effect of these policies as there was significant overlap in the generation eligible for each of these subsidies.

The New Buyback Program for Solar PV

In November 2009, the Japanese Government introduced FITs for small-scale solar PV systems — the '*New Buyback Program for Solar Photovoltaic Generation*' (the Buyback Program). The Buyback Program requires electricity utilities to buy excess electricity generated from PV systems from residential and non-residential sources at a fixed tariff rate for 10 years, the cost of which will be passed on to consumers through a 'solar surcharge'. The current rates of the tariff are:

- ¥48/kWh for residential solar PV less than 10 kW (or ¥39/kWh if generators are coequipped with other forms of generation, such as fuel cells)
- ¥24/kWh for non-residential solar PV (or ¥20/kWh if generators are coequipped) (METI (Japan) 2011b).

The Commission was unable to obtain data on the proportion of eligible generators that were coequipped with other forms of generation. Therefore, the Commission's estimate of the subsidy equivalent for this policy is likely to be an upper bound (as

generators that are coequipped receive a lower FIT rate). However, the Commission considers it unlikely that coequipping (at the residential level) was widespread.

As the Buyback Program has only been in place since November 2009, the Commission estimated the subsidy equivalent and abatement of the program for the period 1 November 2009 to 31 March 2010.

Estimating the subsidy equivalent

The subsidy equivalent of the solar FITs was estimated by multiplying the production subsidy equivalent by total electricity generation from eligible solar PV.

To estimate the production subsidy equivalent, the counterfactual electricity price was subtracted from the FIT rate. The counterfactual electricity price is the price that would have been received for excess electricity generated from solar PV in the absence of the FIT. In Japan, electricity utilities appear to voluntarily pay higher rates for excess electricity generated from residential and non-residential solar PV than for electricity from conventional sources (Ito 2010, IEA 2010a). Ito (2010. p. 2), suggested that the buyback tariff was 'double the "autonomous" purchase price conventionally paid by electric power companies (¥24/kWh for residential and ¥11–¥15/kWh for non residential buildings), when applied to solar PV excess power'.

Therefore, the production subsidy equivalent for residential and non-residential solar PV was estimated to be ¥24/kWh and ¥12/kWh respectively — half of the rates applied under the Buyback Program.

Estimating generation

Generation from solar PV that was eligible for the FIT was 265 GWh over the period 1 November 2009 to 31 March 2010 (METI and ANRE (Japan) 2010).

Data on the proportion of this generation that were from residential and non-residential solar PV were not available. However, according to Ito (2010), the Buyback Program was mainly designed to apply to small-scale solar PV installed in residential buildings. As such, it was anticipated that most solar PV installed under the program would be in residential buildings. Moreover, in 2009 residential PV systems accounted for 89.5 per cent of grid-connected PV in Japan (IEA 2010i).

Therefore, the Commission assumed that 89.5 per cent of the total generation eligible for the solar FIT was from residential sources and 10.5 per cent was from non-residential sources.

Subsidy equivalent

Based on the above assumptions, the subsidy equivalent of the Buyback Program was estimated to be ¥6 billion (A$76 million) (table G.5). The Commission understands that the total value of the Buyback program in 2009 was much higher than this estimate (METI (Japan), pers. comm., 20 May 2011). The Commission was unable to reconcile this difference and has retained the above estimate to maintain consistency in the approach used to estimate the subsidy equivalent of FIT programs in other countries.

Table G.5 **Subsidy equivalent, National Buyback Program**
Japan, April 2009 – March 2010

	Units	*Residential*	*Non-residential*	*Total*
Feed-in tariff rate	¥/kWh	48	24	..
Counterfactual electricity price	¥/kWh	24	12	..
Production subsidy equivalent	¥/kWh	24	12	..
Solar PV generation[a]	GWh	237	28	265
Subsidy equivalent	**¥m (2009)**	**5 688**	**334**	**6 022**
Subsidy equivalent	**A$m (2009)**	**72**	**4**	**76**

[a] Residential and non-residential solar PV generation were assumed to be 89.5 per cent and 10.5 per cent of total generation respectively. **..** Not applicable

Sources: METI and ANRE (Japan) (2010); METI (Japan) (2011a); Productivity Commission estimates.

National Solar Photovoltaic Capital Subsidies

Since 1994 the Japanese Government has provided capital subsidies for the installation of solar PV systems in residential buildings.[1] The rate of the subsidy was ¥70 000/kW (A$880/kW) for solar PV systems with a generation capacity of 10 kW or less in 2009. The federal subsidy was provided in addition to other metropolitan and municipal level subsidies (including the Tokyo Metropolitan Solar PV Subsidy).

Estimating the subsidy equivalent

The Commission obtained data on the total value of subsidies paid out under the program from the IEEJ (IEEJ, pers. comm., 8 April 2011). These data suggest that the total value of the subsidy for the period 1 April 1994 to 31 March 2010 was ¥173 billion (in 2009 ¥) (A$2.2 billion). Assuming a 7 per cent discount rate and an

1 The subsidy program ceased in 2005 but was reinstated in 2007.

asset life of 20 years, the annualised value (subsidy equivalent) of the subsidy was estimated to be ¥16.4 billion (A$206 million).

Estimating generation

The cumulative capacity of solar PV supported by the subsidy program over the period 1 April 1994 to 31 March 2010 was 2.17 GW (IEEJ, pers. comm., 8 April 2011). The annual generation of subsidised solar PV was estimated using a capacity factor of 12 per cent (IEEJ, pers. comm., 8 April 2011). This provided an estimate of annual generation of 2.28 TWh in 2009-10.

Sensitivity analysis

As sensitivity analysis, the Commission varied the discount rate to 3 and 11 per cent:

- Assuming a discount rate of 3 per cent, the subsidy equivalent was estimated to be ¥11.6 billion (A$147 million).
- Assuming an 11 per cent discount rate, the subsidy equivalent was estimated to be ¥21.8 billion (A$274 million).

Based on the above parameter values, the subsidy equivalent of the National Solar PV Subsidy program was estimated to be in the range of ¥11.6 billion (A$147 million) to ¥21.8 billion (A$274 million) in FY 2009 (table G.6).

Table G.6 **Summary, National Solar Photovoltaic Capital Subsidies**
Japan, April 2009 – March 2010

	Units	*Discount rate*		
		3%	7%	11%
Subsidy equivalent[a]	¥b (2009)	11.6	16.4	21.8
Subsidy equivalent	A$m (2009)	147	206	274

[a] The subsidy equivalent was based on an estimate of the total value of the subsidy for the period 1 April 1994 to 31 March 2010 of ¥173 billion (where values have been converted to 2009 ¥ using IMF GDP deflators).

Source: Productivity Commission estimates.

Tokyo Solar Photovoltaic Capital Subsidies

From 1 April 2009 to 31 March 2010 (FY 2009) the Tokyo Metropolitan Government provided capital subsidies for the installation of solar PV systems in residential buildings. The rate of the subsidy was ¥100 000/kW of solar PV installed

(Tokyo Metropolitan Environmental Improvement Corporation 2011). Subsidies were also available for solar water heaters but have been excluded from the Commission's analysis as they apply to heat rather than electricity generation.

Estimating the subsidy equivalent

The total capacity of solar PV supported by the subsidy program for FY 2009 was 25 MW (Tokyo Metropolitan Foundation for Environmental Development 2011). Multiplying this capacity by the value of the subsidy in this period (¥100 000/kW) gives an estimate of ¥2.5 billion (A$32 million) for the total value of the subsidy.

Assuming a 7 per cent discount rate and an asset life of 20 years for solar PV panels, the annualised value (subsidy equivalent) of the subsidy was estimated to be ¥236 million (A$3 million).

Estimating annual generation

Annual generation of subsidised solar PV was estimated using a capacity factor of 12 per cent (IEEJ, pers. comm., 8 April 2011). This provided an estimate of annual generation of 26.3 GWh in FY 2009.

Sensitivity analysis

As sensitivity analysis, the Commission varied the discount rate to 3 and 11 per cent:

- Assuming a discount rate of 3 per cent, the subsidy equivalent was estimated to be ¥168 million (A$2.1 million).
- Assuming an 11 per cent discount rate, the subsidy equivalent was estimated to be ¥314 million (A$4 million).

Based on the above parameter values, the subsidy equivalent of the Tokyo Solar PV Capital Subsidies was estimated to be in the range of ¥168 million (A$2.1 million) to ¥314 million (A$4.0 million) (table G.7).

Estimating abatement from the solar programs

In order to estimate the abatement induced by the solar programs, an estimate of the generation supported by the three schemes was required.

The National and Tokyo capital subsidies and a large part of the Buyback Program all target residential solar panels. The Commission assumed that all owners of residential solar panels that are eligible under these schemes receive all of the subsidies they are eligible for. As such, the residential generation covered by the three schemes was equal to the generation covered by the National PV Subsidies (2.28 TWh).

Table G.7 **Summary, Tokyo Solar Photovoltaic Capital Subsidies**
Japan, April 2009 – March 2010

	Units	*Discount rate*		
		3%	7%	11%
Subsidy equivalent	¥m (2009)	168	236	314
Subsidy equivalent	A$m (2009)	2.1	3.0	4.0

Source: Productivity Commission estimates.

In addition, a component of the Buyback Program was targeted at non-residential solar. As noted above, the Commission assumed that 90 per cent of the Buyback Program tariffs were provided to residential solar. Therefore, the Commission estimated that 28 GWh of non-residential solar generation was covered under the Buyback Program (10 per cent of the generation).

Therefore, the total generation covered by these three schemes was estimated at 2.31 TWh. Using a counterfactual emissions intensity of 0.574 t CO_2/MWh, the estimated abatement from the three schemes was 1.3 Mt CO_2.

Sensitivity analysis

The Commission used an alternate counterfactual emissions intensity of 0.439 t CO_2/MWh. This results in an abatement estimate of 1 Mt of CO_2.

Estimating the implicit abatement subsidy of solar programs

The implicit abatement subsidy of all three solar programs combined was calculated by adding together the three subsidy equivalent estimates, and dividing by the combined estimate of abatement. Based on these estimates, the implicit abatement subsidy of the solar programs was estimated to be between ¥13 450/t CO_2 and ¥27 699/t CO_2 (A$170 and A$349) (table G.8).

Table G.8 **Implicit abatement subsidy, solar programs**

Japan, April 2009 – March 2010 (in 2009 values)

	Subsidy equivalent		*Abatement*	*Implicit abatement subsidy*	
	¥b	A$m	Mt CO_2	¥/t CO_2	A$/t CO_2
Oil counterfactual					
7 per cent discount rate	22.6	285	1	17 052	215
11 per cent discount rate	28.1	354	1	21 184	267
3 per cent discount rate	17.8	225	1	13 450	170
Gas counterfactual					
7 per cent discount rate	22.6	285	1	22 295	281
11 per cent discount rate	28.1	354	1	27 699	349
3 per cent discount rate	17.8	225	1	17 586	222

Source: Productivity Commission estimates.

G.6 Petroleum and Coal Tax

A petroleum tax was introduced in Japan in 1978, and initially only applied to oil. The tax was expanded in 1984 to cover liquefied natural gas and liquefied petroleum gas, and in 2003 it was expanded to cover coal. The tax rates currently stand at ¥2040/kL for oil, ¥1080/t of gas and ¥700/t of coal.

Japan is proposing to progressively lift these tax rates between 2011 and 2016 as part of its environmental tax reform. The rates are expected to rise by 37 per cent for oil, 72 per cent for gas and 96 per cent for coal (Nikkei 2010).

Estimating the subsidy equivalent

Tax rates for FY 2009 were converted into a price per tonne of carbon dioxide emitted from electricity generation from each of these sources. For each fuel, the Commission estimated the amount of fuel used and/or GWh of electricity generated based on the generation from the top ten producers in 2008. This figure, and the emissions intensity of generation of each fuel were used to convert the tax per litre or tonne of fuel into a tax per tonne of CO_2 (table G.9). Tax rates were estimated to be:

- For liquefied natural gas (LNG), the tax per tonne of CO_2 was estimated at ¥366 (A$4.61)
- for coal, the tax per tonne of CO_2 was estimated at ¥266 (A$3.36)
- for oil, the tax per tonne of CO_2 was estimated at ¥822 (A$10.37).

Table G.9 **Estimating the tax per tonne of CO_2**
Japan, FY 2009

	Units	*LNG*	*Coal*	*Oil*
Tax rate (¥)		1080/t	700/t	2040/kL
Generation from the top 10 power producers (2008)[a]	TWh	278	147	79
Fuel used by the top 10 power producers (2008)[a]		41 321 kt	50 774 kt	18 258 ML
Amount of fuel used per GWh		149t	347t	231L
Tax per kWh	¥/kWh	0.16	0.24	0.47
Average emissions intensity of generation	t CO_2/MWh	0.439	0.911	0.574
Tax per tonne of CO_2 (¥)	¥/t	366	266	822
Tax per tonne of CO_2 (A$)	A$/t	4.61	3.36	10.37

[a] The generation from top ten power producers and fuel used from top ten power producers were used to derive the average amount of fuel used per GWh. This was taken as a proxy for all power producers.

Sources: IEEJ (pers. comm., 8 April 2011); IEA (2010a); Productivity Commission estimates.

The Commission considers it unlikely that the fuel tax resulted in any fuel switching between the fossil fuel sources. This is because:

- while oil had the highest tax rate, it is generally already the highest-cost fossil fuel source. As such this will not result in any change in the merit order
- the difference in the tax rate between coal and gas was very small when converted into per unit of electricity (¥0.08/kWh — A$1/MWh). This was unlikely to result in a switch in the merit order between the two sources.

In addition, given the relatively high cost of renewable energy, it was unlikely that the fuel tax was inducing any additional renewable generation on its own. As such, the Commission considers that (in the context of electricity generation) the impact of the fuel tax was to add to the effective subsidy equivalent received by renewable sources 'induced' by other Japanese policies.

The effective subsidy received by renewable generation under this policy was estimated as the electricity price uplift induced by the policy (or alternatively, given the structure of the Japanese market (with VIUs and regulated prices) this can be thought of as the increase in the marginal cost of fossil-fuel-based generation, relative to renewable generation).

Under the Commission's analysis oil was considered to be the marginal generator. Therefore, oil was assumed to be driving the marginal cost of fossil-fuel-based generation, and the effective subsidy received by renewable generators was estimated to be ¥0.47/kWh (A$0.006), or ¥822/t CO_2 abated (A$10.37) (assuming full pass through of costs).

The Commission estimated that 6.5 TWh of renewable electricity was policy-induced in Japan (estimated by dividing the abatement estimate in section G.7 (3.9 Mt CO_2) by the counterfactual emissions intensity (0.574 t CO_2/MWh)). Therefore, the subsidy equivalent of the fuel tax was ¥3.1 billion (A$39 million).

Sensitivity analysis

For sensitivity analysis, the Commission assumed that natural gas was the marginal generator. This implies a subsidy of ¥0.16/kWh (A$0.002/kWh), and therefore, given an induced renewable generation estimate of 6.5 TWh, the subsidy equivalent was estimated at ¥1.1 billion (A$13 million).

G.7 Summary

This section combines the individual policy subsidy equivalent and abatement estimates into country-wide estimates for the total subsidy equivalent, total abatement and the average implicit abatement subsidy for the Japanese electricity sector.

The total subsidy equivalent

The total subsidy equivalent represents an estimate of the total subsidy provided to renewable generation as a result of the policies analysed. This is simply the sum of the individual policy subsidy equivalent estimates. This was estimated to be between ¥53 billion and ¥75 billion (A$669 million and A$940 million) (table G.10) and represents around 0.01 per cent of Japan's GDP.

Total abatement

As the estimates provided above take into account policy overlaps, the abatement estimates can be added together to provide an estimate of total abatement in Japan's electricity sector. This was estimated at between 2.9 Mt CO_2 and 3.8 Mt CO_2 (table G.11).

Given the emissions estimate for 2008 reported in section G.1 (396 Mt CO_2), this abatement estimate represents less than one per cent of Japan's counterfactual electricity sector emissions in 2008.

Table G.10 **Total subsidy equivalent**

Japan, April 2009 – March 2010 (in 2009 values)

Policy	*'Central'*	*High*	*Low*	*'Central'*	*High*	*Low*
	¥b	¥b	¥b	A$m	A$m	A$m
Renewable Portfolio Standard	23.8	23.8	23.8	300	300	300
Project for Promoting the Local Introduction of New Energy	2.1	2.8	1.5	26	35	19
Project for Supporting New Energy Operators	12.3	16.3	8.8	155	206	110
National PV Subsidies	16.4	21.8	11.6	206	274	147
Tokyo PV Subsidies	0.2	0.3	0.1	3	4	2
Feed-In Tariffs	6.0	6.0	6.0	76	76	76
Petroleum and Coal Tax	3.1	3.1	1.1	39	39	13
Total	64	75	53	811	940	669

Source: Productivity Commission estimates.

Table G.11 **Total abatement**

Japan, April 2009 – March 2010

Policy	*'Central'*	*High*	*Low*
	Mt CO_2	Mt CO_2	Mt CO_2
Renewable Portfolio Standard plus wind subsidies	3	3	2
National PV Subsidies, Tokyo PV Subsidies and the Buyback program	1	1	1
Total	4	4	3

Source: Productivity Commission estimates.

The average implicit abatement subsidy

Based on the estimates above, the average implicit abatement subsidy for the Japanese electricity sector was estimated at between ¥12 384/t CO_2 and ¥22 744/t CO_2 (A$156 and A$287) (table G.12).

Table G.12 **Average implicit abatement subsidy**

Japan, April 2009 – March 2010 (In 2009 values)

		Abatement					
		'Central'	*High*	*Low*	*'Central'*	*High*	*Low*
		¥/t CO_2	¥/t CO_2	¥/t CO_2	A$/t CO_2	A$/t CO_2	A$/t CO_2
Total subsidy equivalent	High	17 395	17 395	22 744	219	219	287
	'Central'	15 007	15 007	19 622	189	189	248
	Low	12 384	12 384	16 192	156	156	204

Source: Productivity Commission estimates.

G.8 Excluded and committed policies

Excluded policies

The Commission endeavoured to include all material policies operating at the federal level in Japan. However, there may be policies operating below the federal level, such as capital subsidies for renewable energy provided by metropolitan governments (similar to the Tokyo PV Capital Subsidies) that could have an effect on the estimates. Including these policies would increase the total subsidy equivalent estimate, but is expected to have minimal impact on total abatement (as the abatement is likely to be covered by the federal schemes). Thus, this may mean that the average implicit abatement subsidy estimates are underestimates.

Committed policies

While the Commission did not identify any material Japanese policies which could be classed as 'committed' (aside from increasing the level of the Petroleum and Coal Tax — section G.6), in March 2010 the *Bill of the Basic Act on Global Warming Countermeasures* was introduced into parliament. This Bill proposed the introduction of:

- an emissions trading scheme
- a system of FITs, which would replace the RPS.

The Bill aimed to reduce Japanese emissions to 25 per cent below 1990 levels by 2020. Clearly these would be substantial emissions-reduction measures that, when introduced, the Commission would expect to have a large effect on the implicit abatement subsidy estimation. However, the Bill has not yet been passed into law, and it is unclear when this will occur.

H New Zealand's electricity generation sector

The Commission has identified only one significant emissions-reduction policy that applies in the New Zealand electricity generation sector: the New Zealand Emissions Trading Scheme (ETS). Because the scheme has only applied to electricity since 2010, no data were available to estimate the total subsidy equivalent or electricity sector abatement. Instead, the Commission has carried out a qualitative assessment of the ETS, and drawn on other studies to reach some conclusions about its possible effects on emissions.

H.1 The New Zealand ETS

Under the United Nations' Framework Convention on Climate Change, New Zealand has committed to maintain its average greenhouse gas emissions at 1990 levels over the period 2008–2012. After 2012, New Zealand has committed to reduce its emissions by 10–20 per cent by 2020, conditional on the actions of other countries. As part of its efforts to achieve these targets, New Zealand has had an ETS since 2008. Entities with ETS obligations are required to surrender one New Zealand Unit (NZU) per tonne of CO_2 (although under transitional arrangements currently in place, firms in most covered sectors only have to surrender one permit per two tonnes). Alternatively, they can surrender certain types of Kyoto Protocol emissions-reduction units purchased on international markets. Specifically, entities can meet their New Zealand ETS obligations with Certified Emissions Reductions (CERs) created through the Clean Development Mechanism, Removal Units and Emission Reduction Units.

Initially, the ETS applied only to the forestry sector. Owners of forests planted after 1989 can opt into the ETS and earn NZUs for carbon sequestered in the process of forest growth. Owners of forests also have to pay penalties or surrender NZUs if they deforest or harvest their forests. Stationary energy (including electricity), liquid fossil fuels and some industrial processes were added to the scheme in 2010. The agriculture sector (the source of around 50 per cent of New Zealand's emissions) is currently scheduled to be added in 2015.

Permits have been allocated to activities that are emissions-intensive and trade-exposed, with the objective being to 'prevent a loss of competitiveness and carbon leakage'(Ministry for the Environment (NZ) 2011, p. 12). In addition, permits have been allocated to the fishing industry to compensate for the loss of value of fishing quotas, and to the owners of forests planted before 1990 (to compensate for the loss of land values). These permits can be sold on secondary markets.

The ETS incorporates a transition phase from 1 July 2010 to 31 December 2012. During this period, entities can opt to pay NZ$25 (around A$19) to the New Zealand Government rather than surrendering a permit. This effectively places a cap on NZU prices. Furthermore, entities in the stationary energy, liquid fossil fuel, and industrial processes sectors are obliged to surrender only one permit for every two tonnes of emissions, so the real price of emissions is currently capped at NZ$12.50/t CO_2 (around A$10).

During the transitional phase, the New Zealand Government will meet the costs of any additional emissions reductions necessary to meet New Zealand's international obligations for emissions reductions. The cap on the NZU price is due to run until the end of 2012. The ETS is currently under review, and the Review Panel will examine whether existing transitional arrangements should be extended beyond 2012, taking into account a range of factors including the action taken by other countries.

Estimating the subsidy equivalent

As is the case for the European Union ETS, the New Zealand ETS provides an implicit subsidy to lower-emissions generators, with the value of the implicit abatement subsidy per tonne of CO_2 being equal to the permit price. In the initial months after the introduction of the New Zealand ETS, the volume of trade in NZUs was light. Trade in permits spiked in March 2011 as a result of the Fukushima nuclear accident in Japan (Point Carbon 2011b). In response to the accident, the German Government shut down seven nuclear power plants for three months. This was expected to lead to increased use of fossil fuels in Germany's electricity generation sector, which in turn increased the demand for CERs (CERs had been widely used by New Zealand firms to meet their ETS obligations). The increased demand for CERs meant that many New Zealand entities that had previously purchased CERs to meet their New Zealand ETS obligations (because the price of CERs was below the NZ$25 (A$19) price firms could pay to the Government instead of purchasing permits) found it profitable to sell their CERs

and purchase NZUs (which were now priced below the CER price). This led to an increase in the demand for, and price of, NZUs.

Data from Point Carbon (2011a, 2011b, 2011c) suggest that in early 2011 spot prices for NZUs have been in the range of NZ$19 to NZ$21 (around A$14–16). Hence, the NZU price cap of NZ$25 (A$19) has not been binding over this period. However, since emitters are currently required to surrender only one NZU per two tonnes of emissions, the implicit abatement subsidy is effectively half of the price (around A$7–8/t CO_2).

Estimating ETS-induced abatement

In order to assess the level of abatement attributable to the ETS, it is necessary to estimate the extent of fuel switching. This will be influenced by the structure of New Zealand's electricity generation sector. In 2010, around 74 per cent of electricity in New Zealand was generated using renewable energy, with the majority of that being hydro (around 56 per cent of total generation). Geothermal power accounts for around 13 per cent of total generation, and wind for around 4 per cent. Coal accounted for around 5 per cent of total generation, and gas 21 per cent (MED (NZ) 2011a).

Given the existing high use of renewables, New Zealand's electricity generation sector has relatively few opportunities to reduce emissions through fuel switching in the short term (New Zealand Government 2007). The Ministry of Economic Development (MED) has carried out modelling of the New Zealand electricity sector to analyse the effects of the ETS. The modelling does not provide results that could be used to estimate a subsidy equivalent or electricity generation sector abatement arising from the New Zealand ETS today, but does give an indication of the possible effects of the scheme on the fuel mix in New Zealand over the longer term.

The MED has forecast that by 2030, electricity sector emissions will return to around 1990 levels (after peaking in 2006). The reduction in emissions is forecast to come from a reduction in the use of coal — the MED has forecast that New Zealand's only coal-fired power plant will be phased out over time (with operations to cease by around 2021), and no new coal-fired plant will be built. It has also forecast that two gas-fired plants will close, but will be replaced by new gas plants, leading to no net change in gas-fired generation capacity. (While the MED does not speculate on the efficiency of the new plants, it is possible that the ETS could provide an incentive for the owners to build plants with lower emissions

intensity, leading to some abatement.) Growth in electricity demand is forecast to be met by an increase in the use of geothermal, hydro and wind power.

Given the relatively low price of NZUs, and the high level of renewables in the New Zealand electricity generation mix, the New Zealand ETS is probably not currently leading to much abatement in the electricity generation sector. This could change over time. The implicit abatement subsidy under the New Zealand ETS is simply equal to the permit price of around NZ$10/t CO_2 (A$8).

Other potential sources of abatement under the New Zealand ETS

While New Zealand appears to have relatively few options for reducing its emissions from the electricity generation sector, the inclusion of forestry in the scheme is one mechanism that New Zealand can use to achieve abatement. The Ministry for the Environment (NZME 2011b) has published a forecast of New Zealand's greenhouse gas emissions to 2050. It appears that afforestation (tree planting) will be responsible for a significant proportion of New Zealand's greenhouse gas emissions reduction in that period. However, it should be noted that abatement through tree planting is cyclical, and emissions associated with harvesting will be incurred in the longer term. International instruments (such as CERs) could also play a significant role in meeting emissions targets.

I South Korea's electricity generation sector

I.1 Introduction

The Commission has estimated the subsidy equivalent, abatement and implicit abatement subsidy for six policies in South Korea: Feed-in Tariffs (FITs) for renewable energy; preferential loans for renewable energy; the Korea Certified Emission Reduction (KCER) scheme; and three capital subsidy programs — the Regional Deployment Subsidy program, the General Deployment Capital Subsidy program, and the 'One Million Green Homes' program.

In addition to these programs, the South Korean Government has committed to the introduction of Renewable Portfolio Standards and mandatory emissions-reduction targets for large emitters (including power generators). An emissions trading scheme has also been proposed for introduction (section I.12).

2009 was the most recent year for which data were available for most measures. Hence, subsidy equivalents and abatement were estimated for the 2009 calendar year and then converted to 2010 dollars using International Monetary Fund GDP deflators for South Korea (IMF 2011). Subsidy equivalents and implicit abatement subsidies are reported in both South Korean Won (KRW) and Australian dollars (A$), with currency conversion rates based on the average exchange rate for 2010 of A$0.000939/KRW (RBA 2011).

References in this appendix to Vivid Economics refer to unpublished data supplied to the Productivity Commission by that contractor. The relevant data are provided on the Productivity Commission's website where there are no commercial-in-confidence restrictions.

I.2 Electricity generation in South Korea

The South Korean electricity market

The South Korean electricity market is largely state owned and regulated, though efforts have been made to liberalise the generation market.

Traditionally, the largely government-owned Korea Electric Power Corporation (KEPCO) has owned the generation, transmission and retail assets. In 2001, KEPCO's generation assets were split across six subsidiaries. Efforts were made to privatise some of these entities, but this did not go ahead. As of August 2010, the government has taken direct control of five of the subsidiaries, with only the nuclear assets remaining 'independent' as a subsidiary of KEPCO (EIA (US) 2010b).

There are also a number of independent power producers. As of 2009, these were responsible for 13 per cent of generation capacity in South Korea (KPX 2010a).

The majority of power produced in South Korea must be dispatched through a mandatory pool, which is operated by the Korea Power Exchange. This pool is a 'cost-based pool' system — unlike standard electricity pools, generators do not submit bids. Rather, they submit their availability for a time period, with the merit order (and thus the system marginal price) based on an assessment of each generator's marginal cost (KPX 2010a).

In general, aside from renewable generation, generators do not receive the system marginal price. Rather, the price they receive is based on estimates of their marginal cost, plus an adjustment that takes into account the difference between their marginal cost and the marginal price (KEPCO 2008).

The South Korean market also features capacity payments — generators are paid for capacity they make available during a period, regardless of whether the capacity is required in that period or not. In 2009, the capacity payment averaged KRW 7.71/kWh, and approximately 14.8 per cent of payments to generators was in the form of the capacity payment (KPX 2010a).

KEPCO is the sole retailer in South Korea. Therefore, aside from large wholesale purchasers, KEPCO is the sole purchaser of electricity from the pool.

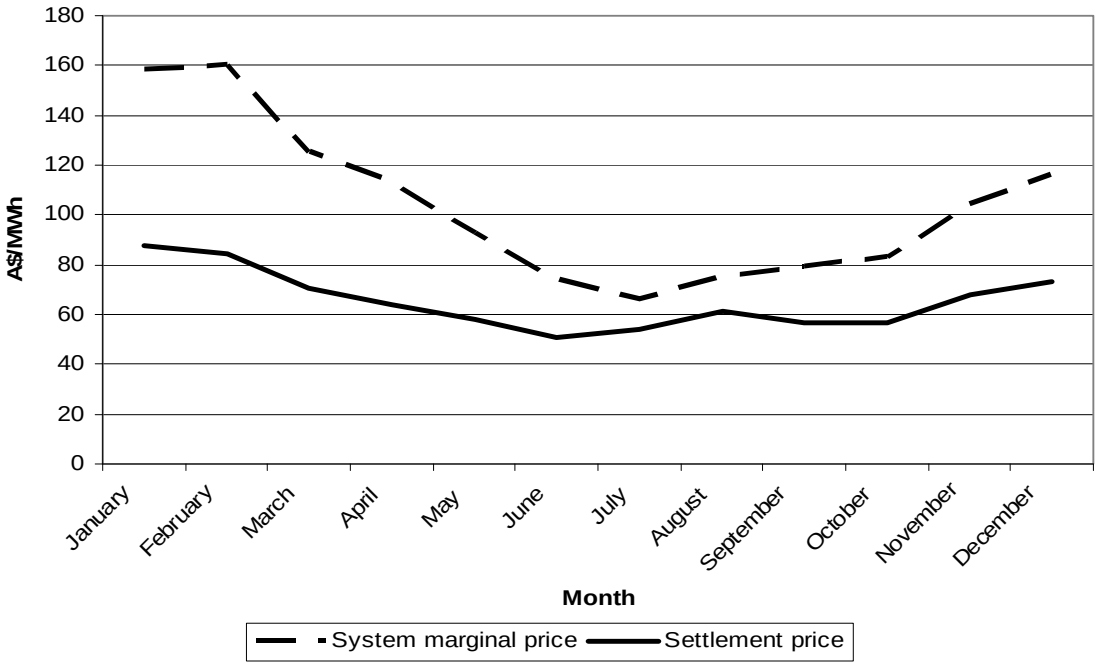
Key statistics

Electricity prices

The average system marginal price fluctuated over 2009, with electricity prices high during winter (with a peak of KRW 161/kWh (A$0.16) in February) and declining during summer (with a low of KRW 66/kWh (A$0.07) in July (figure I.1)). The average system marginal price in 2009 was approximately KRW 105/kWh (A$0.10).

The average settlement price was more stable, reflecting the fact that this is based largely around the marginal costs of generators. The average settlement price in 2009 was KRW 66/kWh (A$0.07). Note that the settlement price is the average price generators receive, as opposed to the system marginal price which is the price of the marginal generator.

Figure I.1 **Electricity prices[a]**
South Korea, 2009



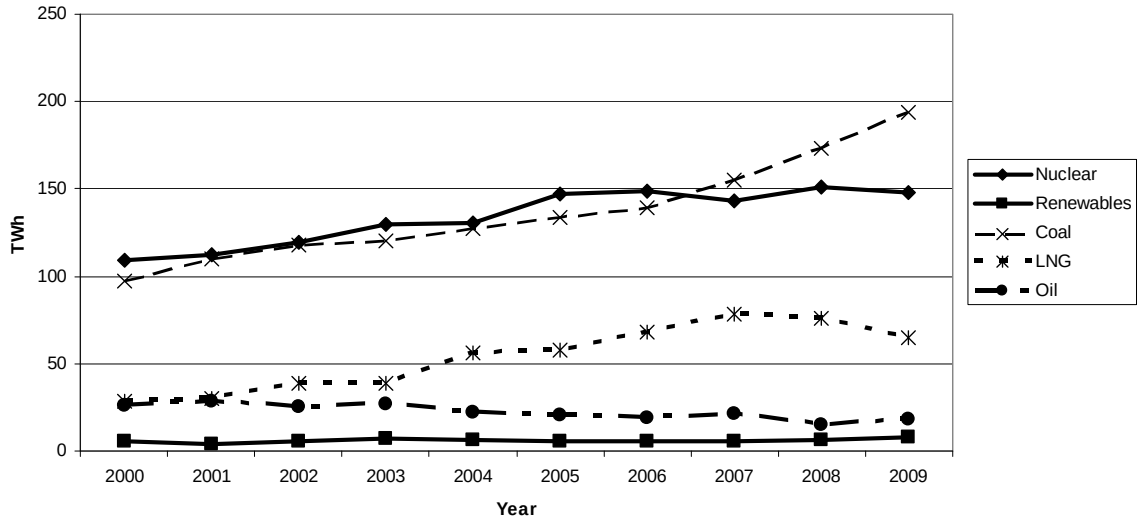
a System marginal price is the average price of the marginal generator. Settlement price is the average price received for dispatched generation. Converted to Australian dollars using the average 2009 exchange rate A$0.000993/KRW.

Source: KEEI pers. comm., 9 April 2011.

Generation mix

South Korea's electricity generation is dominated by a mix of coal and nuclear baseload power (figure I.2). Liquefied Natural Gas (LNG) and oil make up a smaller proportion of the generation mix, and are largely peak-load generators. The share of renewable generation is small, but increasing. In 2009, renewables generated approximately 8 TWh (up from 5.6 TWh in 2005), of which over half was hydroelectricity.

Figure I.2 **Electricity generation**
South Korea, 2000–2009



Source: KPX (2010b).

Emissions

The Commission was unable to locate data on emissions from the electricity sector. Emissions in the electricity and heat sectors combined in 2008 were 191 Mt CO_2, of which almost 80 per cent was from coal (IEA 2010a).

Note that in 2008 there was approximately 446 TWh of electricity generation (89 per cent) and 56 TWh of heat (11 per cent) (IEA 2010h). This implies an average emissions intensity of 0.43 t CO_2/MWh for electricity and heat generation.

I.3 Estimating abatement in South Korea

In order to estimate the abatement attributable to each policy, the Commission has used data provided by Vivid Economics (2011).

The Commission's analysis of abatement is based on identifying the marginal generator in a country's electricity market as this is the generator that is expected to be displaced from the merit order when renewable energy is installed. The marginal generator will always receive the highest price, while other generators will often receive a price that is lower than the system marginal price, based on a percentage of their variable costs (new and renewable energy sources are exempt from this, and simply receive the system marginal price). As such, generators that receive a higher price can be assumed to have higher variable costs, and therefore are more likely to be marginal generators.

According to the Korean Power Exchange (KPX 2010b), the three generators that received the highest average price over 2009 were pumped storage, oil and gas based generators. The emissions intensity of pumped storage generation is equal to the emissions intensity of the generator used to pump the water, plus some efficiency loss. The Commission does not have information on the emissions intensity of the pumped storage and for this reason has not included it in its estimates of the emissions intensity of the marginal generator. Instead, the Commission has assumed that oil and gas were the marginal generators.

According to Vivid Economics (2011), the average emissions intensity of oil generation in South Korea is 0.653 t CO_2/MWh and LNG's emissions intensity is 0.39 t CO_2/MWh.

The Commission has considered three scenarios in its estimates (table I.1).

- In the 'central' scenario, both LNG and oil are the marginal generation source 50 per cent of the time. This results in an average counterfactual emissions intensity of 0.522 t CO_2/MWh.
- The other two scenarios assume that either LNG or oil is the marginal generator 100 per cent of the time. This results in average counterfactual intensities of 0.39 t CO_2/MWh and 0.653 t CO_2/MWh respectively.

Table I.1 **Counterfactual scenarios**
South Korea, 2009

Scenario	*Counterfactual emissions intensity*
	t CO_2/MWh
'Central'	0.522
LNG counterfactual	0.390
Oil counterfactual	0.653

Sources: Vivid Economics (2011); Productivity Commission estimates.

I.4 Policy overlaps

The Commission has estimated subsidy equivalents and abatement attributable to six policies: Feed-in Tariffs for renewable energy, preferential loans for renewable energy; the KCER scheme; and three capital subsidy programs — the Regional Deployment Subsidy program; the General Deployment Capital Subsidy program; and the 'One Million Green Homes' program. The Commission considers that the overlap between each of these policies is limited:

- Generators are only eligible for the feed-in tariffs if the subsidy they receive is less than 30 per cent of the costs (KEMCO 2010). Therefore, it is unlikely that firms receiving a capital subsidy could be eligible for the FITs, given that these schemes typically subsidised over 50 per cent of costs, and as such, abatement is not being 'double counted'.
- It is likely that generators receiving a preferential loan could be part of other subsidy schemes, such as the FITs and the General Deployment Subsidies. Therefore, it is likely that the loans program fully overlaps with the other policies analysed.
- KCERs appear to be created for the installation of more efficient fossil fuel generation. As such, this scheme will not overlap with the renewable energy schemes.

The Commission was unable to obtain data on the extent of the overlaps between the Loans Incentive Program and the other policies analysed. As such, the subsidy equivalent for the Loan Incentive Program has been estimated separately, and no abatement or implicit abatement subsidy has been estimated for this policy. As generation receiving the FITs (or other subsidies) could also receive the loans, this means that the policy implicit abatement subsidy estimates are likely to be a slight under-estimate of the true implicit abatement subsidy to the generation supported by each policy.

I.5 Feed-in Tariffs

The Korean Feed-in Tariffs (FITs) offer fixed or variable tariffs for a range of new and renewable energy sources, including solar photovoltaic (PV), wind, fuel cells, waste and biomass, hydroelectricity and wave and tidal energy. Many of these installations have the option of:

1. a fixed tariff — for most of the sources apart from PV and fuel cells this appears to be below the average system marginal price
2. a variable tariff — often set at KRW 5–20/kWh (approximately A$0.005–A$0.02/kWh) above the system marginal price.

The most generous tariffs are set for solar PV, which has received 86 per cent of the total subsidy since the scheme was introduced in 2002, despite only contributing 15 per cent of FIT-eligible generation. Tariffs of up to KRW 700/kWh are available for solar PV installations (approximately A$0.70/kWh) — well above the average system marginal price of KRW 105/kWh in 2009 (KPX 2010b).

The FITs are expected to run until 2012, when they are expected to be replaced by the South Korean Renewable Portfolio Standard (KEMCO 2010).

Estimating the subsidy equivalent

The Korean Energy Economics Institute (KEEI) (pers. comm., 9 April 2011) stated that, in 2009, KRW 263 billion of FITs were paid out by the South Korean Government to new and renewable energy sources. Converted to 2010 KRW, the total subsidy equivalent was estimated to be KRW 271 billion (A$255 million).

As the Government pays the difference between the wholesale price and the FIT rate, this is the subsidy equivalent paid out.

Estimating abatement

According to the KEEI (pers. comm., 9 April 2011), 1.5 TWh of generation was supported by the FITs in 2009. Although data on the generation capacity that already existed prior to the FITs were not available, the Commission considers it likely that most generation that existed prior to the introduction of FITs would have received a subsidy from either the Regional Deployment Subsidy or the General Deployment Subsidy (which both existed prior to the introduction of the FITs). Generators receiving these subsidies are not eligible for FITs.

This generation is multiplied by the emissions intensity of replaced generation — estimated to be 0.522 t CO_2/MWh (section I.3) — to estimate abatement of 785 kt CO_2.

Estimating the implicit abatement subsidy

Based on the above estimates, the implicit abatement subsidy was estimated to be KRW 345 990/t CO_2 (A$325).

Sensitivity analysis

There is some uncertainty about the emissions intensity of the marginal generator. To address this, the Commission analysed the effects of varying the emissions intensity of the counterfactual generator:

- Using a counterfactual emissions intensity of 0.39 t CO_2/MWh, the implicit abatement subsidy was estimated to be KRW 463 095/t CO_2 (A$435/t CO_2).
- Using a counterfactual emissions intensity of 0.65 t CO_2/MWh, the implicit abatement subsidy was estimated to be KRW 277 857/t CO_2 (A$261/t CO_2).

Summary

Table I.2 outlines the results of the estimation for the South Korean FITs. The implicit abatement subsidy estimates range from KRW 277 857/t CO_2 to KRW 463 095/t CO_2 (A$261 to A$435), due to variations in the assumptions about the counterfactual emissions intensity.

Table I.2 **Summary, South Korean FITs**
South Korea, 2009 (in 2010 values)

Scenario	*Subsidy equivalent*		*Abatement*	*Implicit abatement subsidy*	
	A$m	KRW b	Mt CO_2	A$/t CO_2	KRW/t CO_2
Central' counterfactual	255	271	0.8	325	345 990
Oil counterfactual	255	271	1	261	277 857
Gas counterfactual	255	271	0.6	435	463 095

Source: Productivity Commission estimates.

I.6 Korea Certified Emission Reductions

Since 2005, a voluntary market for KCERs has operated in South Korea. Companies that abate more than 500 tonnes of emissions a year are eligible to receive KCERs — where one KCER is created per tonne of CO_2 abated. Based on advice from the KEEI (pers. comm., 15 April 2011) it appears that KCERs created in the electricity sector are for efficiency improvements in fossil fuel generation. KCERs can be purchased in the market for around KRW 4800/t (Vivid Economics). However, in practice the Government tends to purchase the KCERs as there is no domestic obligation for emission reductions or KCER purchase.

Estimating the subsidy equivalent

The Commission has estimated the subsidy equivalent of the KCERs using an approach similar to the one used for renewable energy certificates — where the total subsidy equivalent is equal to the certificate price (price of KCERs) multiplied by the number of certificates created. However, because the KCER market is a voluntary one, companies creating KCERs only receive a subsidy equivalent upon the sale of the KCER. Moreover, as the Commission's focus is on the electricity sector, only KCERs created by electricity generators are relevant to the analysis.

The Commission used the following approach to determine how many electricity generation-related KCERs were created and subsequently purchased by government:

- In 2009, 2.7 million KCERs were generated, of which 2.2 million were purchased by the Government (Vivid Economics). Information from the KEEI (pers. comm. 14 April 2011) suggests that there is no market for the purchase of KCERs outside those that are purchased by government.
- Of all KCERs created between 2007 and 2010, approximately 1.1 million were created by electricity generators (KEEI, pers. comm., 13 April 2011)[1]. This is equivalent to 12 per cent of all KCERs over the period 2007–2010 (8.8 million).
- Applying this proportion to the number of KCERs purchased by government in 2009 suggests that 272 772 of the 2.2 million KCERs purchased by government were from electricity generators.

The price paid by government per KCER was KRW 4837 in 2009. Multiplying this price by the Commission's estimate of the number of electricity KCERs purchased

1 The Commission was unable to obtain data on the number of electricity sector KCERs created per year. Therefore the total over the period 2007–2010 was used.

by government in 2009 gives a subsidy equivalent of KRW 1.4 billion (A$1.3 million) in real 2010 values (table I.3).

Table I.3 **Subsidy equivalent, KCERs**
South Korea, 2009

Variable	*Value*
Subsidy equivalent (KRW 2009)	1.3b
Subsidy equivalent (real 2010 KRW)	1.4b
Subsidy equivalent (real 2010 A$)	1.3m

Source: Productivity Commission estimates.

Estimating abatement

As noted above, it appears that KCERs were mainly created for more efficient fossil fuel electricity generation (for example, the introduction of high-efficiency gas turbines and ultra-supercritical generation). This suggests that abatement from the program does not appear to overlap with that from other measures analysed by the Commission (section I.4). Nonetheless, as each KCER represents one tonne of CO_2 abated, the Commission has assumed that abatement from the KCER program is equivalent to the total number of electricity sector KCERs created and purchased in 2009, which was estimated to be 273 kt CO_2.

Implicit abatement subsidy

The implicit abatement subsidy of the KCER scheme is simply the permit price (in 2010 KRW) — KRW 4992/t CO_2 (A$4.75).

I.7 Regional Deployment Subsidy scheme

The Regional Deployment Subsidy scheme provides an upfront capital subsidy for renewable energy systems in regional areas. The subsidy is available for:

- building infrastructure to support renewable energy — up to 100 per cent of costs
- building renewable energy systems (both electricity and heat) — up to 60 per cent of costs.

The Commission's estimates only consider subsidies for building renewable electricity — infrastructure and heat have not been included.

Estimating the subsidy equivalent

Since 2000, a total of KRW 477 billion of subsidies have been granted under the regional deployment subsidy. According to the KEEI (pers. comm., 9 April 2011), KRW 290 billion of this amount was paid for the installation of solar PV, biomass, wind and small hydroelectricity systems (which are assumed to be renewable electricity).

As this subsidy is provided over a number of years, the annual value of the subsidy has been deflated to 2010 KRW. This results in a subsidy of KRW 324 billion to renewable electricity in real terms.

Using the standard approach to estimating capital subsidies — with a discount rate of 7 per cent and an expected economic life of 20 years — the annualised subsidy equivalent has been estimated to be KRW 31 billion (A$29 million) (table I.4).

Table I.4 **Subsidy equivalent, Korean Regional Deployment Subsidy**
South Korea, 2009

Variable	*Value*
Total subsidy (2010 KRW)	KRW 324b
Discount rate	7 per cent
Expected economic lifetime of assets	20 years
Subsidy equivalent (2010 KRW)	KRW 31b
Subsidy equivalent (2010 A$)	A$29m

Source: Productivity Commission estimates.

Estimating abatement

The Commission obtained data on total generation from subsidised sources since the commencement of the scheme. In order to estimate abatement, this needed to be converted into generation in 2009.

In order to do this, it was assumed that generation was installed each year in proportion to the amount of the subsidy given. Each unit of generation was assumed to generate an equal amount per year.

Using this approach, annual generation from the subsidised sources was estimated at:

- 82 GWh from solar PV
- 9.3 GWh from hydroelectricity

- 21 GWh from wind
- 18.3 GWh from waste and biomass.

Therefore, the total annual generation subsidised by the scheme is estimated at 130 GWh.

As noted in section I.3, the average counterfactual emissions intensity is estimated to be approximately 0.522 t CO_2/MWh. Therefore, the estimated abatement of the Regional Deployment Subsidy is 68 kt CO_2.

Estimating the implicit abatement subsidy

Using the Commission's estimates of the subsidy equivalent and abatement outlined above, the implicit abatement subsidy of the Regional Deployment Subsidy is estimated at KRW 449 612/t CO_2 (A$422).

Sensitivity analysis

The Commission has performed two sets of sensitivity analysis for the regional deployment subsidy — varying the discount rate, and varying the counterfactual.

Varying the discount rate

The Commission has used two alternative discount rates for sensitivity analysis — 3 and 11 per cent:

- Using a discount rate of 11 per cent results in an implicit abatement subsidy of KRW 598 141/t CO_2 (A$562).
- Using a discount rate of 3 per cent results in an implicit abatement subsidy of KRW 320 162/t CO_2 (A$301).

Varying the counterfactual emissions intensity

As noted in section I.3, the Commission has used two alternative emissions intensity scenarios.

- If an emissions intensity of 0.39 t CO_2/MWh is used, the implicit abatement subsidy estimate is KRW 600 403/t CO_2 (A$564).
- If an emissions intensity of 0.65 t CO_2/MWh is used, the implicit abatement subsidy estimate is KRW 359 690/t CO_2 (A$338).

Summary

Table I.5 displays a summary of the estimates for the Regional Deployment Subsidy. The estimates range from KRW 320 161 to KRW 600 403/t CO_2 (A$301 to A$564).

Table I.5 **Summary, Regional Deployment Subsidy**
South Korea, 2009 (2010 values)

Scenario	*Subsidy equivalent*		*Abatement*	*Implicit abatement subsidy*	
	KRW b	A$m	Mt CO_2	KRW	A$/t
'Central'	31	29	0.07	449 612	422
High discount rate	41	38	0.07	598 141	562
Low discount rate	22	20	0.07	320 161	301
Counterfactual emissions intensity of 0.65	31	29	0.09	359 690	338
Counterfactual emissions intensity of 0.39	31	29	0.05	600 403	564

Source: Productivity Commission estimates.

I.8 General Deployment Subsidy scheme

The General Deployment Subsidy scheme offers upfront capital subsidies to established renewable technologies, including solar and wind. The subsidy supports up to 50 per cent of the costs of installing a renewable energy system (KEMCO 2010).

This subsidy scheme also provides a subsidy to renewable heat technologies, such as geothermal and solar thermal. These subsidies are not included in the estimates, as they do not apply to electricity generation.

Estimating the subsidy equivalent

As of the end of 2009, the General Deployment Subsidy scheme had provided KRW 76 billion to renewable electricity generators (KEEI pers. comm., 9 April 2011). Data were available on the subsidy paid out per year, and this was converted to 2010 values using the South Korean GDP deflator. The total value of the deployment subsidy to renewable electricity generators in 2010 values was KRW 86 billion.

The cost of the capital subsidy has been annualised using a discount rate of 7 per cent and an expected lifetime of 20 years. This provides an estimate of the subsidy equivalent of KRW 8 billion (A$8 million) (table I.6).

Table I.6 **Subsidy equivalent, General Deployment Subsidy**
South Korea, 2009 (in 2010 values)

Variable	*Value*
Real value of electricity subsidies	KRW 86b
Discount rate	7 per cent
Economic lifetime of subsidised sources	20 years
Subsidy equivalent (KRW)	KRW 8b
Subsidy equivalent (A$)	A$8m

Source: Productivity Commission estimates.

Estimating abatement

Since the commencement of the subsidy program, these subsidies have supported:

- 11.32 MW of solar PV
- 390 kW of wind
- 5.9 MW of biomass
- 1 kW of fuel cells.

These capacity values have been converted into annual generation using capacity factor estimates. Solar is assumed to have a capacity factor of 12.6 per cent (IEA 2010b). However, data on the capacity factors for other generation sources were not available, and these were estimated.

Using data from the IEA (2010e; 2010h), average capacity factors in South Korea were estimated to equal 25 per cent for wind, 47 per cent for biomass, and 35 per cent for fuel cells (table I.7).

Based on this, the Commission estimated annual generation from each source. Using a counterfactual emissions intensity of 0.522 t CO_2/MWh, the abatement from the General Deployment Subsidy was estimated to be 20 kt CO_2 (table I.8).

Estimating the implicit abatement subsidy

From the above estimates, the implicit abatement subsidy was estimated to equal KRW 411 967/t CO_2 (A$387).

Table I.7 **Estimating capacity factors**
South Korea, 2008

Generation source	*Capacity in South Korea*	*Generation in South Korea*	*Estimated capacity factor*
	MW	GWh	%
Wind	190	414	25
Biomass	170	700	47
Fuel cells[a]	20	62	35

[a] Fuel cell data are from KEEI (pers. comm., 9 April 2011), and represent the fuel cells receiving FITs in 2009.

Sources: IEA (2010e; 2010h).

Table I.8 **Estimating abatement — General Deployment Subsidy**
South Korea, 2009

Generation source	*Capacity*	*Capacity factor*	*Estimated annual generation*	*Counterfactual emissions intensity*	*Abatement*
	MW	%	MWh	t CO_2/MWh	Mt CO_2
Wind	0.4	25	843	..	..
Solar	11.3	10	12 492	..	..
Biomass	5.9	47	24 257	..	..
Fuel cells	0.001	35	3	..	..
Total	17.6		37 596	0.522	0.02

.. Not applicable.

Sources: KEEI (pers. comm., 9 April 2011); Productivity Commission estimates.

Sensitivity analysis

Varying the discount rate

Two scenarios were estimated, one with a discount rate of 3 per cent, and the other with a discount rate of 11 per cent. With a low discount rate, the implicit abatement subsidy was KRW 293 356/t CO_2 (A$275) and with a high discount rate the estimate was KRW 548 061/t CO_2 (A$515).

Varying the counterfactual

Two alternate counterfactual scenarios were considered:

- If the counterfactual emissions intensity was 0.65 t CO_2/MWh (section I.3), the implicit abatement subsidy was estimated to be KRW 330 842/t CO_2 (A$311).

- If the counterfactual emissions intensity was 0.39 t CO_2/MWh, the implicit abatement subsidy was estimated to be KRW 551 403/t CO_2 (A$518).

Summary

Table I.9 displays the results of the estimation, including the sensitivity analysis. The estimates of the implicit abatement subsidy range from approximately KRW 293 356/t CO_2 to KRW 551 403/t CO_2 (A$275 to A$518).

Table I.9 **Summary, General Deployment Subsidy**
South Korea, 2009 (in 2010 values)

Scenario	*Subsidy equivalent*		*Abatement*	*Implicit abatement subsidy*	
	KRW b	A$m	Mt CO_2	KRW/t CO_2	A$/t CO_2
Baseline	8	8	0.02	411 967	387
Discount rate of 11 per cent	11	10	0.02	548 061	515
Discount rate of 3 per cent	6	5	0.02	293 356	275
Counterfactual intensity of 0.65	8	8	0.02	330 842	311
Counterfactual intensity of 0.4	8	8	0.01	551 403	518

Source: Productivity Commission estimates.

I.9 One Million Green Homes

The 'One Million Green Homes' program provides subsidies for the installation of a range of renewable energy systems in residential homes. Subsidies are provided to cover up to 50 per cent of the installation costs for roof-top solar PV, small-scale solar thermal and geothermal, and small-scale hydroelectricity and wind. The objective of the program is for one million South Korean homes to be using one of these renewable energy sources by 2020.

In 2009, the One Million Green Homes program subsumed the '100,000 solar-roof installations program' and expanded the coverage of subsidies to other renewable systems. As a result, the large majority of renewable generation supported by the program up until the end of 2009 relates to roof-top solar — around 90 per cent of the total subsidies paid out under the program.

Estimating the subsidy equivalent

The Commission has estimated the total subsidy equivalent for solar PV and small-scale hydroelectricity subsidies paid out over the period 2004 to 2009.[2] The total value of the subsidies was KRW 247 billion (in 2010 real KRW). Using a discount rate of 7 per cent, and an expected useful economic life of generation assets of 20 years, the annualised subsidy equivalent of the One Million Green Homes program is KRW 23 billion (A$22 million) (table I.10).

Table I.10 **Subsidy equivalent, One Million Green Homes**
South Korea, 2004 to 2009 (in 2010 values)

Variable	*Value*
Real value of PV subsidies (2010 KRW)	247b
Discount rate	7 per cent
Useful economic life of generation assets	20 years
Subsidy equivalent (KRW (2010))	23b
Subsidy equivalent (A$ (2010))	22m

Source: Productivity Commission estimates.

Estimating abatement

The total installed capacity of renewable electricity supported by the program until the end of 2009 was 43.7MW, with an annual generation of 48 GWh. Annual generation for solar roof-top systems is estimated using a capacity factor of 12.6 per cent (IEA 2010b) and for small-scale hydroelectricity using a capacity factor of 2.5 per cent (IEA 2010e; IEA 2010h).

The Commission has used the 'central' counterfactual emissions intensity of 0.52t CO_2/MWh (section I.3). Based on this, abatement was estimated to be 25 kt CO_2 (table I.11)

Implicit abatement subsidy

Based on the Commission's estimate of the subsidy equivalent and abatement, the implicit abatement subsidy of the One Million Green Homes program was estimated to be KRW 922 661/t CO_2 (A$866).

[2] The subsidy was also provided to solar-thermal and geothermal. However, this has been excluded from the analysis as it is assumed to relate to heat rather than electricity. As of the end of 2009, no subsidies were paid out to small-scale wind.

Table I.11 **Abatement, One Million Green Homes**
South Korea, 2009

Variable	*Value*
Total installed capacity (MW)	44
Capacity factor (%)	12.6
Annual generation (GWh)	48
Counterfactual emissions intensity (t CO_2/MWh)	0.522
Abatement (Mt CO_2)	0.03

Sources: KEEI (pers. comm., 9 April 2011); IEA (2010b; 2011e; 2010h); Productivity Commission estimates.

Sensitivity analysis

The Commission has undertaken sensitivity analysis on two parameters, the discount rate and the counterfactual emissions intensity.

Discount rate

Using discount rates of 3 and 11 per cent, the implicit abatement subsidy of the One Million Green Homes program is estimated to be KRW 657 012/t CO_2 (A$617) and KRW 1.2 million/t CO_2 (A$1152) respectively.

Counterfactual emissions intensity

Using a counterfactual emissions intensity of 0.39 t CO_2/MWh, the implicit abatement subsidy is estimated to be KRW 1.2 million/t CO_2. (A$1156).

Using a counterfactual emissions intensity of 0.65 t CO_2/MWh, the implicit abatement subsidy is estimated to be KRW 737 704/t CO_2 (A$693).

Summary of estimates

The Commission's estimates of the subsidy equivalent, abatement, and implicit abatement subsidy for the One Million Green Homes program are summarised in table I.12. These estimates imply an implicit abatement subsidy in the range KRW 657 012/t CO_2 (A$617) to KRW 1.2 million/t CO_2 (A$1156).

Table I.12 **Summary, One Million Green Homes**
South Korea, 2009

Scenario	*Subsidy equivalent*		*Abatement*	*Implicit abatement subsidy*	
	KRW b (2010)	A$m (2010)	Mt CO_2	KRW/t CO_2	A$/t CO_2
'Central'	23	22	0.03	922 661	866
Discount rate of 11 per cent	31	29	0.03	1.2m	1 152
Discount rate of 3 per cent	17	16	0.03	657 012	617
Counterfactual intensity of 0.65	23	22	0.03	737 704	693
Counterfactual intensity of 0.39	23	22	0.02	1.2m	1 156

Source: Productivity Commission estimates.

I.10 Loan Incentive Program

The South Korean Government offers long-term low-interest rate loans for both the installation and operation of new and renewable energy generators. Operation loans are provided either for the construction of renewable energy facilities or for the operation and management of renewable energy facilities. Preferential loans are provided for up to 90 per cent of the total cost (50 per cent for large corporations) (KEMCO 2010) and are repayable in 10 years (KEEI pers. comm., 21 April 2011).

The Commission considers the Loan Incentive Program to fully overlap with other policies in South Korea, such as the FITs and the General Deployment Subsidy. As a result, only the subsidy equivalent for the Loan Incentive Program has been estimated — abatement and the implicit abatement subsidy has not been estimated as abatement is assumed to have been counted under the other schemes.

Estimating the subsidy equivalent

The Commission's approach to estimating the subsidy equivalent of preferential loans is to estimate the total value of loans outstanding in 2009, and then estimate the difference in the annual repayments of these loans using the preferential interest rate offered under the program and that which would have applied had the preferential rate not been offered. The difference in the annual repayments is the subsidy equivalent of the program.

Value of loans outstanding in 2009

The Commission obtained data on the total value (and renewable energy source) of loans supported by the loan incentive program over the period 1983 to 2009 (table I.13).

Table I.13 **Total value of loans by renewable energy source**[a]
South Korea, 1983–2009

	1983–2004	*2005*	*2006*	*2007*	*2008*	*2009*	*Total*
				KRW b			
Solar thermal	155.1	1.0	0.0	0.4	0.0	0.3	156.9
Photovoltaic	9.7	24.3	48.2	98.8	163.6	90.6	435.3
Bioenergy	80.9	27.6	8.4	2.8	4.3	0.0	124.0
Waste	86.4	4.2	11.9	5.2	0.0	0.0	107.7
Hydroelectricity	37.0	6.3	7.6	3.5	2.6	1.8	58.8
Geothermal	5.1	2.5	2.7	3.1	0.4	0.0	13.9
Wind	14.0	28.9	36.2	4.9	3.5	20.6	108.3
Fuel cell	7.8	5.0	4.6	1.9	4.4	11.1	34.7
Total (electricity)[b]	236	96	117	117	178	124	869
Total (electricity) (2010 KRW)	334	108	131	129	190	128	1 020
Total (electricity) (2010 A$m)	314	101	123	121	179	120	958

a The Commission was unable to obtain the necessary information to disaggregate the data in table I.13 by 'operation loans' and 'installation loans'. Operation loans are provided either for the manufacture of renewable energy facilities or for the operation and management of renewable energy facilities. Ideally, the manufacture of renewable energy facilities would be excluded from the Commission's analysis as it does not strictly apply to the electricity generation sector. However, based on data provided by KEEI (pers. comm., 9 April 2011), only 1.5 per cent of total loans supported were operation loans (of which a lesser amount would be for manufacture of renewable energy facilities). Therefore they have not been subtracted from the total value of loans. **b** The total for electricity generation is estimated by summing the value of loans for photovoltaic, bioenergy, waste, hydroelectricity, wind and fuel cells. Solar thermal and geothermal are assumed to be used for the generation of heat and therefore have been excluded from the estimate.

Sources: KEEI (pers. comm., 9 April 2011); Productivity Commission estimates.

These data suggest that over the period 1983–2009 the total value of loans (in real 2010 values) provided to renewable electricity generators was approximately KRW 1020 billion (A$958 million).

As the preferential loans are payable in ten years (KEEI, pers. comm., 15 April 2011) the Commission has estimated the subsidy equivalent of the preferential loan program using loans provided over the period 2000–2009.

However, as indicated in table I.13, data on the value of loans to renewable electricity generators are only available on an annual basis from 2005 onwards. Therefore, the Commission used the following approach to estimate the proportion of loans that were provided to renewable electricity generators in the period 2000–2004:

- Based on data from the KEEI (pers. comm., 9 April 2011) the value of loans supported over the period 1983–2004 was KRW 397 billion (A$373 million) and the value of loans supported between 2000–2004 was KRW 135 billion (A$130 million). Therefore the proportion of loans supported in the period 2000–2004 was 34 per cent.
- Applying this proportion to the total value of electricity sector supported loans in the period 2000–2004 (table I.14) provides an estimate of KRW 114 billion (A$107 million) (in 2010 values).
- Adding this value to the annual value of electricity sector supported loans over the period 2005 to 2009 gives an estimate of total supported electricity sector loans (in 2010 values) of KRW 799 billion (A$751 million).

Annual loan repayments

To estimate the annual repayments on these loans, the Commission used the following formula (which is consistent with the approach applied to estimating the subsidy equivalent of explicit capital subsidies):

$$R_i = [\ P_i * r\ ] / [(1 - (1+r)^{-n_i})\ ]$$

where:

R_i = annual loan repayment

P_i = the principle value of loans outstanding in 2010

r = interest rate

n_i = the economic life of the asset

The subsidy equivalent of the Loan Incentives Program was estimated to be the difference between:

- the annual loan repayment using the preferential interest rate
- the annual loan repayment using the rate that would have applied if the investor was not offered a preferential rate.

According to the KEEI (pers. comm., 21 April 2011) the preferential rate was 2.75 per cent. For the alternative rate — which would have applied had the investor been required to privately finance the loan — the Commission has used the standard commercial rate that applied in South Korea in February 2011. This was 5.81 per cent (KEEI pers. comm., 21 April 2011).

Based on a 2.75 per cent interest rate, the annual repayment was estimated to be KRW 53 billion (A$49 million) in 2010.

Based on a 5.81 per cent commercial interest rate, the annual repayment was estimated to be KRW 67 billion (A$64 million) in 2010.

This implies a difference of KRW 16 billion (A$15 million), which was the subsidy equivalent of the program.

Sensitivity analysis

If it is assumed that a higher commercial interest rate would have applied in the absence of the preferential loan program — assumed to be 11 per cent in line with the Commission's highest sensitivity value used in other parts of this study — then the subsidy equivalent of the loan incentives program was estimated to be KRW 48 billion (A$45 million).

I.11 Summary

This section combines the individual policy estimates to provide an estimate of the total subsidy equivalent, total abatement and the average implicit abatement subsidy for South Korea's electricity generation sector.

The total subsidy equivalent

The individual policy subsidy equivalents represent an estimate of the subsidy granted to low-emissions generation by each policy. These can be added together to provide an estimate of the total subsidy equivalent to low-emissions generation in South Korea.

The total subsidy equivalent for South Korea was estimated at between KRW 333 billion and KRW 403 billion (A$313 million and A$379 million) (table I.14). This represents around 0.03 per cent of South Korea's GDP.

Table I.14 **Total subsidy equivalent**

South Korea, 2009 (In 2010 values)

Schemes	*Central*	*High*	*Low*	*'Central'*	*High*	*Low*
	KRW b	KRW b	KRW b	A$m	A$m	A$m
Regional Deployment Subsidy	31	41	22	29	38	20
1 Million Green Homes	23	31	17	22	29	16
General Deployment Subsidy	8	11	6	8	10	5
Feed-in tariffs	271	271	271	255	255	255
Loans	16	48	16	15	45	15
KCERs	1	1	1	1	1	1
Total	351	403	333	329	379	313

Source: Productivity Commission estimates.

Total abatement

The Commission considers that overlaps between South Korea's policies is limited (section I.4). In the one example where overlap was deemed to be an issue (in the case of the Loan Incentive Program) abatement was not estimated for this policy. Thus the policy abatement estimates can be added together, to provide an estimate of total abatement in South Korea's electricity sector. The total abatement is estimated to be between 0.9 Mt CO_2 and 1.4 Mt CO_2 (table I.15), which represents less than one per cent of South Korea's 2008 counterfactual electricity sector emissions.

Table I.15 **Total abatement**

South Korea, 2009

	Central	*High*	*Low*
	Mt CO_2	Mt CO_2	Mt CO_2
Regional Deployment Subsidy	0.07	0.09	0.05
One Million Green Homes	0.03	0.03	0.02
General Deployment Subsidy	0.02	0.02	0.01
Feed-in tariffs	0.8	1	0.6
KCERs	0.3	0.3	0.3
Total	1	1	0.9

Source: Productivity Commission estimates.

The average implicit abatement subsidy

Using the estimations above, the Commission has estimated an implicit abatement subsidy for the South Korean electricity generation sector. This was estimated to be between KRW 239 476 and 427 286/t CO_2 (A$225 and A$401) (table I.16).

Table I.16 **Average implicit abatement subsidy**
South Korea, 2009 (in 2010 values)

	Implicit abatement subsidy					
Total subsidy equivalent scenario	*High abatement*	*'Central' abatement*	*Low abatement*	*High abatement*	*'Central' abatement*	*Low abatement*
	KRW/t CO_2	KRW/t CO_2	KRW/t CO_2	A$/t CO_2	A$/t CO_2	A$/t CO_2
High	289 859	344 484	427 286	272	323	401
'Central'	252 303	299 850	371 923	237	282	349
Low	239 476	284 606	353 015	225	267	331

Source: Productivity Commission estimates.

I.12 Other South Korean electricity generation policies

The Commission's analysis for South Korea is considered to reflect the large majority of electricity generation measures that exist in South Korea. However, two policies were excluded from the analysis that may have had a material effect on the total subsidy equivalent estimates for South Korea. Moreover, the South Korean Government has committed to the introduction of a number of measures that could also materially affect future analyses.

Excluded policies

The following electricity sector measures were identified but not estimated due to data constraints:

- The 'Green New Deal' — an economic stimulus package announced in 2009. The package includes a plan to spend US$1.8 billion between 2009–2012 on 'Low-Carbon Power Renewable' measures (HSBC 2010). The Commission was unable to obtain specific information on the nature of electricity generation measures funded by the Green New Deal in 2009 and 2010.
- Tax deductions — approximately 20 per cent of the investment cost of new and renewable energy systems can be deducted from income tax or corporate income tax (KEMCO 2010).

The exclusion of these two measures may have resulted in the Commission underestimating the total subsidy equivalent for the South Korean electricity sector. However, they are not expected to bias the Commission's estimates of abatement. To the extent that they are focused on renewable electricity — and therefore overlap with other measures, in particular Feed-in Tariffs — they are unlikely to have contributed additional abatement.

Committed policies

The Commission identified a number of emission reduction measures that the South Korean Government has committed to in the electricity generation sector:

- The Greenhouse Gas and Energy Target Management Scheme — a system of mandatory emission reduction agreements covering 374 companies (including 36 electricity generators) that emit more than 25 000 t CO_2 per year. The scheme is expected to include an offset system.
- Renewable energy portfolio standards (RPS) — a requirement for large fossil fuel electricity generators (plants over 500 MW) to source a proportion of their total electricity production from renewable sources — starting at 2 per cent in 2012 (KEMCO 2010). The RPS will include a renewable energy certificate trading scheme, which is expected to replace the current Feed-in Tariff program. Based on information provided by KEEI (pers. comm., 9 April 2011), the RPS certificate price was estimated to be KRW 200–300/kWh (A$0.19–0.28/kWh) for solar PV and KRW 40/kWh (approximately A$0.04/kWh) for other new and renewable electricity sources.
- Emissions trading scheme — proposed for implementation in 2015. The Commission understands that the South Korean Government is considering the use of KCERs in the emissions trading scheme although details of the policy are unclear at this stage.

The combined effect of these policies may be to increase the total abatement and total subsidy equivalent for the South Korean electricity generation sector — to the extent that they provide a larger subsidy equivalent to renewable generators. However, they will be offset to some extent by changes to existing measures. For example, the Feed-in Tariff is expected to be replaced by the RPS and the KCER scheme is expected to be rolled into the proposed emissions trading scheme.

J The United Kingdom's electricity generation sector

The Commission has estimated the subsidy equivalent for four policies in the United Kingdom: the European Union Emissions Trading Scheme (ETS), the Renewables Obligation, the Climate Change Levy (CCL) and the Offshore Wind Capital Grants Scheme.

In addition, the Commission has estimated the implicit abatement subsidies arising from the feed-in tariff (FIT) scheme that commenced in April 2010 (but has not estimated abatement or a subsidy equivalent). Several other policies were considered, but preliminary analysis suggested that the effect of these policies on emissions iwas unlikely to be material in comparison to the other policies analysed, and accordingly the subsidy equivalent and abatement were not estimated.

Subsidy equivalents and abatement were estimated for the 2009-10 financial year (1 April 2009 to 31 March 2010). Subsidy equivalents and implicit abatement subsidies are reported in both UK pounds and Australian dollars, with currency conversion rates based on the average exchange rate for the period April 2009 to March 2010 (£1 = A$1.86). (One exception to this is the FIT scheme, for which the estimate was based on the 2010 calendar year average exchange rate — £1 = A$1.68. This is because the policy did not commence operation until April 2010.)

For the four policies that were analysed in detail, the Commission carried out sensitivity analysis. The results of the sensitivity analysis are reported in comparison to the Commission's 'central' estimate. The 'central' estimate is based on the set of assumptions that the Commission considers to be most consistent with its approach to estimating subsidy equivalents and abatement.

References in this appendix to Frontier Economics refer to unpublished data supplied to the Productivity Commission by that contractor.

J.1 Electricity generation in the United Kingdom

This section is broken into two parts. The first describes the structure of UK electricity markets, while the second reports some key statistics.

Structure of UK electricity markets

Electricity generation, transmission and retail in the United Kingdom are mostly privately-owned (with the exception of some nuclear generators). There are essentially two weakly-linked electricity markets in the United Kingdom. A single market operates in Great Britain. Northern Ireland is not a part of this market, but operates in a single market with the Republic of Ireland. The Great Britain and Northern Ireland wholesale markets will be discussed separately. The other major components of their electricity systems — transmission and retail — are not described. Some remote communities (such as some Scottish Islands) are not connected to the national grid, and rely on imported fossil fuels (such as diesel) and increasingly, renewable sources. These communities constitute a relatively small proportion of total UK electricity generation, and are not assessed separately.

Great Britain wholesale electricity market

The Great Britain market was liberalised throughout the 1990s, and electricity dispatch operates under a market system whereby generators sell electricity to retailers and other large buyers. Most of the UK electricity generation sector is privately-owned, aside from a small amount of nuclear power (IEA 2006). Wholesale electricity is traded in 30 minute blocks. Wholesale trade is decentralised, in contrast to central pool arrangements common in many other electricity markets. Market players are free to trade as they wish, and contracts can be brokered on over-the-counter markets or via exchanges.

National Grid, the entity that operates the UK transmission system, plays a role in balancing demand and supply across 30 minute blocks. This is done by accepting bids to increase or decrease generation or consumption. In the case of additional generation, participants bid the price they would be willing to sell the electricity for, and successful participants receive the price they bid for their electricity (as opposed to other electricity markets including the National Electricity Market in Australia, where all participants receive the highest market clearing bid). According to ELEXON (2011), 98 per cent of trading is done via forward and future markets, with only 2 per cent via this balancing mechanism.

Northern Ireland wholesale electricity market

In 2007, Ireland and Northern Ireland combined to form the Single Electricity Market. Unlike the Great Britain electricity market, the Single Electricity Market is a mandatory pool market — all electricity bought and sold in Ireland must be transacted through the central pool. Generators and suppliers place bids through the central pool and the generators that are scheduled to supply electricity receive the highest market clearing bid.

The Single Electricity Market also features payments to generators for providing reserve capacity to the market. Revenue to make the payments is raised through reserve capacity charges on purchasers of electricity.

Electricity transfers

The electricity system in Great Britain is connected to Northern Ireland through the Moyle interconnector, which has an export capacity of around 450 MW (from Great Britain) and an import capacity of around 80 MW (into Great Britain). The interconnector with France has a capacity of around 2000 MW. Connections are also being constructed with the Republic of Ireland and the Netherlands. There are a number of connections between Northern Ireland and the Republic of Ireland (EirGrid 2011). The United Kingdom was a small net energy importer between 2005 and 2009 (DECC (UK) 2010a).

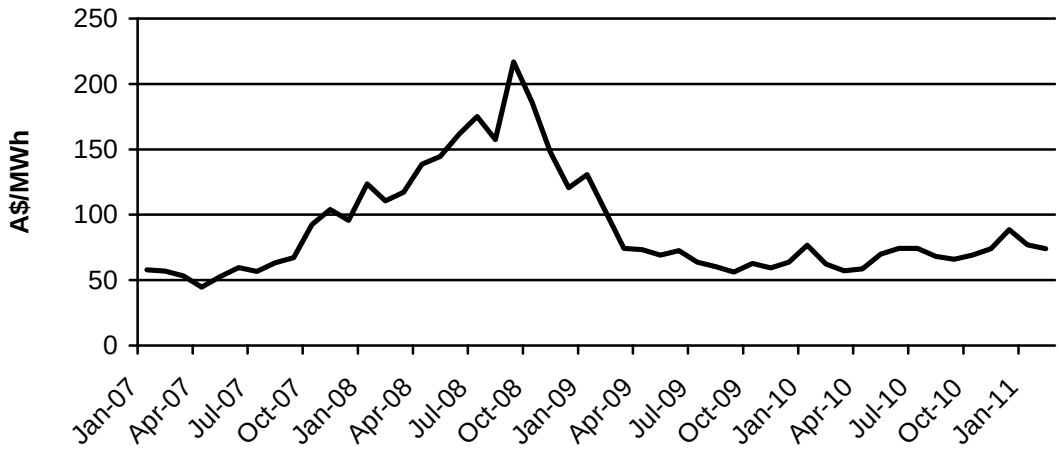
Key statistics

Electricity prices

The average monthly wholesale price of electricity in Great Britain rose significantly in 2008, before falling in 2009 to around A$58/MWh. It has remained at around this level since mid-2009 (figure J.1). The lowest average monthly price was observed in April 2007 at around A$44/MWh. The highest average monthly price was observed in September 2008 at around A$216/MWh. The most recent data available show an average monthly price of around A$80/MWh in early 2011.

Figure J.1 **Monthly average wholesale electricity prices**

Great Britain, Nominal prices, 2007–2011



Source: Frontier Economics (unpublished data).

Electricity generation

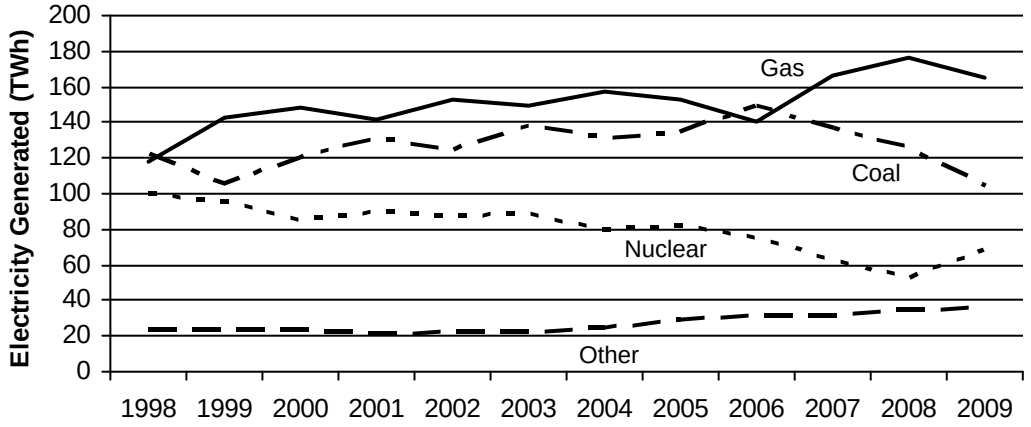
The UK electricity sector has been dominated by three energy sources — coal, gas and nuclear (figure J.2). The share of electricity generated using gas has increased in recent years, and was responsible for around 44 per cent of UK generation in 2009. Renewables (which make up a large proportion of the 'other' category in figure J.2) have also increased their share to around 8 per cent of UK generation in 2009. Biomass is the largest source of renewable generation in the United Kingdom accounting for around 11 TWh of electricity in 2009 (table J.1). Wind generated around 9 TWh of electricity in that year, and is the next largest source of renewable generation. The amount of wind power has increased rapidly in recent years.

Emissions

Emissions from the UK electricity generation sector have fallen since the early 1990s (figure J.3). This is in large part due to the increased use of renewable energy and gas at the expense of coal (which is relatively emissions intensive — table J.2). In 2009, carbon dioxide emissions from the UK electricity generation sector were around 150 Mt.

Figure J.2 **Electricity generated by fuel type[a]**

United Kingdom, 1998–2009



a 'Other' includes hydroelectricity (natural flow and pumped storage), wind, 'other renewables', oil and 'other fuels'.

Source: DECC (UK) (2010c).

Table J.1 **Renewable generation[a]**

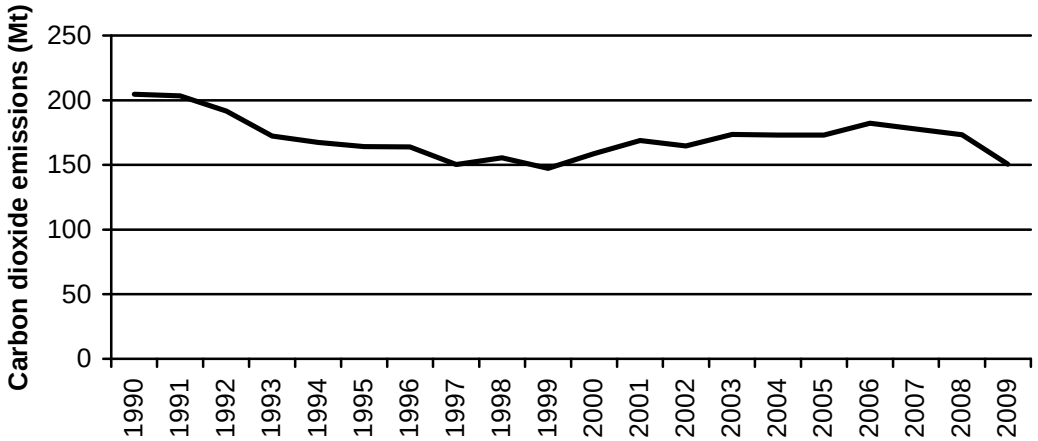
United Kingdom, 2009

Renewable	*Generation (GWh)*
Onshore wind	7 564
Offshore wind	1 740
Solar photovoltaic	20
Hydroelectricity (small scale)	598
Hydroelectricity (large scale)	4 664
Biomass	
Landfill gas	4 952
Sewage sludge digestion	638
Municipal solid waste combustion	1 511
Co-firing with fossil fuels	1 806
Animal biomass	620
Plant biomass	1 109
Total biomass	10 636
Total renewable generation	25 222

a Does not include non-biodegradable waste.

Source: DECC (UK) (2010a).

Figure J.3 **Emissions for the UK electricity generation sector[a]**
United Kingdom, 1990–2009



a Estimates for 2009 are preliminary.

Source: DECC (UK) (2010c).

Table J.2 **Emissions intensity of power generation**
United Kingdom, 2009

Electricity source	*Emissions intensity*
	t CO_2/MWh
Coal	0.915
Oil	0.633
Gas	0.405
Fossil fuels (weighted average)	0.598
All sources (weighted average)	0.452

Source: DECC (UK) (2010a).

J.2 Estimating abatement in the United Kingdom

In order to estimate 2009-10 abatement for each policy, assumptions were made about the source (and emissions intensity) of electricity that has been replaced by the new renewable or lower emissions technology.

The Commission has attempted to identify the marginal generator displaced by the new renewable or low-emissions source in order to estimate the marginal emissions factor. For the United Kingdom, the Commission has considered three approaches to identify the marginal source:

- Frontier Economics — the 'merit order' approach
- Hawkes (2010) — an empirical approach

- the UK Department of Energy and Climate Change (DECC) — the 'build margin' approach.

The Commission's preferred approach — Frontier Economics

Using data on the costs of various plants (or types of plants) to construct a 'merit order', and actual demand during each period, it is possible to identify the marginal plant for each period. This can be used to estimate what the subsidised lower-emissions electricity is replacing during each time period. This is the Commission's preferred approach to estimating the abatement achieved by UK policies.

According to Frontier Economics (unpublished data), the marginal generator in the United Kingdom is generally either coal or combined-cycle gas turbines. Which one is marginal for any given time period depends on costs (in particular fuel prices) and the demand for electricity. In addition, at very high levels of demand, open-cycle gas turbines or oil may become the marginal generator. Therefore, the marginal generator can differ depending on the time of day and year.

Based on the UK merit order and historical demand, Frontier Economics (unpublished data) estimated the average marginal generation source in the 2009-10 financial year to have an emissions intensity of 0.565 t CO_2/MWh. This intensity is higher during the winter, and also during the day (table J.3).

Table J.3 **Emissions intensity of the marginal generator**
United Kingdom, 2009-10, by time of day and year

Time of year	*Day*	*Night*
	t CO_2/MWh	t CO_2/MWh
Summer	0.593	0.412
Winter	0.717	0.538

Source: Frontier Economics (unpublished data).

As the emissions intensity of the marginal generator differs by the time of day and year, it is possible to estimate the emissions intensity displaced by some renewable sources:

- Poyry (2010) suggests that both offshore and onshore wind produce more electricity during the winter than during the summer. In addition, in the case of onshore wind, generation is higher during the night. Based on this, the average emissions intensity of generators displaced by wind was estimated to be slightly

higher than the average emissions intensity of generators displaced by other sources (table J.4).

- Solar photovoltaic (PV) only produces electricity during the daytime and produces more during summer than winter. Frontier Economics estimated the emissions intensity of generators displaced by solar PV to be slightly higher than the average emissions intensity of generators displaced by other sources (table J.4).

Table J.4 **Average emissions intensity displaced by various generation sources**

United Kingdom, 2009-10

Source	*Counterfactual emissions intensity*
	t CO_2/MWh
Offshore wind	0.582
Onshore wind	0.587
Solar PV	0.610
All other	0.565

Source: Frontier Economics (unpublished data).

For other generation sources (biomass, landfill gas, hydroelectricity, sewage gas, tidal and wave, and combined heat and power (CHP)) the average marginal generator has been used as the counterfactual.

Hawkes (2010)

As an alternative to the merit order approach, Hawkes (2010) employed an empirical approach to estimate marginal emissions factors in Great Britain. This approach is based on the idea that a precise merit order is not always observed in practice. More specifically, Hawkes states that:

> The logistics of plant operation, transmission constraints, plant availability, and the vertically integrated nature of many utilities could all provide incentives or constraints that encourage operation in contravention of what is suggested by merit order. (Hawkes 2010, p. 5979)

To address these issues, Hawkes performed regression analysis using historical operating data on the observed dispatch of generators (aggregated into fuel/technology types) in the British electricity system over the period 2002 to 2009. This analysis yielded an average marginal emissions factor of 0.69 t CO_2/MWh — compared to a average grid emissions intensity of 0.51 t CO_2/MWh. The analysis also showed that the marginal emissions factor was lower late at night and early in the morning and higher during peak times.

Department of Energy and Climate Change (DECC) (UK) (2010)

The UK Government uses a long-run emissions factor in calculating abatement estimates — that is, what plant would be 'built or retired in response to policies that result in long-term changes to electricity demand or supply' (DECC (UK) 2010e, p. 9). While not consistent with the Commission's estimation of subsidy equivalents in a single year, the counterfactual emissions intensity from this analysis is included for sensitivity analysis.

The DECC (UK) has predicted, based on a model of the energy sector, that closed-cycle gas turbine plants will be the marginal generation plant built until 2025, and will replace any existing thermal plants that are retired. According to the DECC (UK) (2010e), combined-cycle gas turbine generation has an emissions intensity of 0.39 t CO_2/MWh.

J.3 Policy overlaps

The Commission has made estimates for four UK policies — the Renewables Obligation, the CCL, Offshore Wind Capital Grants and the European Union ETS. However, there is considerable overlap and interaction between these policies:

- Most firms receiving Renewable Obligation certificates (ROCs) are also eligible to receive an exemption under the CCL. These firms also receive a benefit from the European Union ETS. Offshore wind farms can receive a capital grant in addition to these three subsidies.
- There are some renewable generators receiving the CCL exemption that do not receive ROCs (or are not counted by the Commission as leading to additional abatement under the Renewables Obligation).
- CHP generators only receive a benefit under the CCL.
- A coal–gas switch is induced through the European Union ETS.

In order to account for these overlaps and interactions, the Commission has not estimated abatement separately for all policies. Instead, the Commission:

- has reported abatement and implicit abatement subsidies for the Renewables Obligation
- has attributed abatement to the renewables component of the CCL (though an implicit abatement subsidy was not calculated), as some abatement covered under the CCL was not covered under the Renewables Obligation

- has not reported abatement or implicit abatement subsidies for the Offshore Wind Capital Grants Scheme and the renewable energy component of the European Union ETS
- has estimated abatement and implicit abatement subsidies for the CHP component of the CCL, and the coal–gas switch induced by the European Union ETS (because generators receiving these subsidies were already covered under the Renewables Obligation).

It should be noted that while much of the renewable energy abatement was attributed to the Renewables Obligation, this is not necessarily the case in practice. In reality, the abatement was likely to be caused by a combination of the policies. For example, a wind farm may need the subsidies it received through the Renewables Obligation, the CCL and the European Union ETS to be financially viable. Implicit abatement subsidies for the renewable energy schemes combined are reported in section J.9.

J.4 The Renewables Obligation

The Renewables Obligation is a renewable energy certificate scheme operating in the United Kingdom. Eligible generation (including landfill and sewage gas, wind, solar, hydroelectricity, biomass, tidal geothermal, wave and 'energy crops') creates certificates (ROCs) that must be purchased by electricity retailers. The Renewables Obligation commenced in 2002 in England, Wales and Scotland, and in 2005 in Northern Ireland.

In 2009-10, the target was for over 30 million ROCs to be surrendered (corresponding to approximately 30 TWh of renewable generation). However, this target was not met (around 21 million ROCs were surrendered (Ofgem (UK) 2011b)), and in general, the renewable target has not been met in prior years. Instead, many retailers opt to pay a buy-out price (set at £37.19 per ROC in 2009-10). The money raised from this is mostly recycled back to retailers (called the recycle fund), in proportion to the number of ROCs surrendered.

Since April 2009, generators do not all necessarily create one ROC per MWh. Generators installed after this date create differing numbers of ROCs, depending on the technology used — for example, solar PV creates two ROCs per MWh, whereas sewage gas creates 0.25 ROCs per MWh.

In addition, as of April 2010, small-scale generation has been moved into the Feed-in Tariffs scheme (section J.8).

Estimating the subsidy equivalent

The subsidy equivalent of a renewable certificate scheme is simply the certificate price, multiplied by the number of certificates issued to additional generation.

An estimate of the 'value' of a ROC can be calculated based on the buyout price, and the value of the recycle fund. In 2009-10, the buyout price was £37.19, and £15.17 was recycled back to retailers for each ROC surrendered. Therefore, the value of a ROC (or the certificate price for which a retailer will be indifferent between surrendering a certificate or paying the buyout price) will be £52.36.

In the most recent period for which data were available (covering April 2009 to March 2010), 21.2 million ROCs were issued to renewable generators. The total value of these ROCs was estimated to be £1.1 billion (A$2.1 billion).

However, the Commission is interested in the additional generation induced by the policy — the subsidy to pre-existing generation is simply a transfer payment, and should not be included in the estimates. Therefore, the number of ROCs received by generators installed prior to 2002 was 'netted out'.

The amount of eligible renewables (not including large-scale hydroelectricity, as pre-2002 hydroelectricity was not eligible to receive ROCs) existing in 2001 is shown in table J.5. Using data on the number of ROCs received per MWh by each energy source, and assuming that pre-2002 plants are generating at 2001 levels, the number of ROCs received by pre-existing generation was estimated to be 5.1 million. Therefore, an estimated 16.1 million ROCs were received by post-2001 generators.

The subsidy equivalent to these generators was estimated to be £845 million (A$1.6 billion) (table J.6).

Abatement

The abatement attributable to a policy is the amount of low-emissions electricity induced by the policy, multiplied by the difference between the emissions of the subsidised source and the emissions intensity of the counterfactual generator.

Of the 20..3 TWh of renewable generation receiving ROCs in 2009-10, 4.8 TWh was estimated to be produced by generators that already existed in 2001. This leaves a total of 15.5 TWh of 'induced' generation.

Table J.5 **Generation in 2001 by source[a]**

United Kingdom, 2001

	Generation	*ROCs per MWh*	*ROCs*
	GWh	ROCs/MWh	No.
Wind	965	1	965 000
Solar	2	2[b]	4 000
Small-scale hydroelectricity	210	1.002	210 421
Landfill gas	2 507	1.074	2 692 803
Sewage digestion	363	1.074	389 790
Animal biomass	542	1.074	582 170
Plant biomass	234	1.074	251 343
Total	4 823		5 095 533

a Based on the banding for solar PV. Other estimates were based on data in Ofgem (UK) (2011b). **b** Note that these values are likely to represent an over-estimate of the number of ROCs received by pre-existing generation, as some of these sources may have shut down, or not be eligible for ROCs. However, it represents the best available estimate of the ROCs received by pre-existing generators.

Sources: DECC (UK) (2010d); Ofgem (UK) (2011b).

Table J.6 **Subsidy equivalent, Renewables Obligation**

United Kingdom, April 2009 – March 2010

	Value
Number of certificates issued to post-2001 generators	16.1m
Estimated ROC price	£52.36
Subsidy equivalent	£845m (A$1.6b)

Sources: Ofgem (UK) (2011b); Productivity Commission estimates.

Of this additional generation, 6.3 TWh was onshore wind, 2.1 TWh was offshore wind, and an estimated 3.4 GWh was solar PV (based on the number of ROCs received by solar PV, and the banding for solar PV).

Based on the counterfactual emissions intensity estimated by Frontier Economics, as outlined in section J.2, the abatement achieved by the Renewables Obligation was estimated to be 8.9 Mt CO_2 (table J.7).

Implicit abatement subsidy

Based on the above calculations, the implicit abatement subsidy was estimated to be £95/t CO_2 (A$176).

Table J.7 **Abatement, Renewables Obligation**

United Kingdom, April 2009 – March 2010

Source	*Amount of 'induced' generation*	*Counterfactual emissions intensity*	*Abatement*
	GWh	t CO_2/MWh	Mt CO_2
Offshore wind	2 089	0.582	1.2
Onshore wind	6 273	0.587	3.7
Solar PV	3	0.610	–
Other	7 147	0.565	4
Total	15 512		8.9

– Nil or rounded to zero.

Sources: Ofgem (UK) (2011b); Productivity Commission estimates.

Sensitivity analysis

Two parameters were altered during sensitivity analysis — the ROC price and the counterfactual emissions intensity.

Varying the price of ROCs

In reality, the ROC price may be higher or lower than the estimate used above. e-ROC (2011) is an online auction for ROCs, that contains actual data on permit prices. (Note that over the 2009-10 period, this reflects a limited subset of the ROC market — just over 500 000 ROCs, out of 21.2 million ROCs created). The average ROC price for these auctions over the 2009-10 period was £50.20.

Using this value as the certificate price, the subsidy equivalent was estimated as £810 million (A$1.5 billion), and the implicit abatement subsidy was £91/t CO_2 (A$169).

Altering the counterfactual

As noted in section J.2, two alternate counterfactual scenarios have been considered.

- In the first scenario, based on a regression analysis by Hawkes (2010), the counterfactual emissions intensity was estimated to be 0.69 t CO_2/MWh. Using this counterfactual, the implicit abatement subsidy was estimated to equal £79/t CO_2 (A$147).
- The second scenario was based on the 'build margin' (what would be built in the long run in the absence of the policy) estimated by the UK Government, and

uses a counterfactual emissions intensity of 0.39 t CO_2/MWh. This results in an implicit abatement subsidy of £138/t CO_2 (A$257).

Summary

The results of the Renewables Obligation estimations are in table J.8. The estimated implicit abatement subsidy ranges from approximately £79–£138/t CO_2 (A$147–A$257).

Table J.8 **Summary, Renewables Obligation**
United Kingdom, April 2009 – March 2010

Scenario	*Subsidy equivalent (UK pounds)*	*Subsidy equivalent (Australian dollars)*	*Abatement*	*Implicit abatement subsidy (UK pounds)*	*Implicit abatement subsidy (Australian dollars)*
	£b	A$b	Mt CO_2	£/t CO_2	A$/t CO_2
'Central'	0.9	1.6	8.9	95	176
Alternate ROC price	0.8	1.5	8.9	91	169
Hawkes (2010) counterfactual	0.9	1.6	10.7	79	147
'Build margin' counterfactual	0.8	1.6	6.1	138	257

Source: Productivity Commission estimates.

J.5 The Climate Change Levy (CCL)

The CCL is a 'single-stage' sales tax on electricity supplied to non-domestic customers.[1] A number of supplies are excluded or exempt from the levy, including electricity from renewable sources, and good-quality CHP.[2]

1 In addition to electricity, the levy is applied to the supply of the following fossil fuels used for lighting, heating and power: natural gas; petroleum and hydrocarbon gas in a liquid state; coal and lignite; coke, and semi-coke of coal or lignite; and petroleum coke.

2 Relevant electricity generation related exemptions for the CCL are as follows: supplies for domestic use, and for the non–business use of charities; small quantities of fuel and power (assumed to be for domestic use); supplies not for burning or consumption in the United Kingdom; supplies to electricity producers (other than self supplies); supplies to certified CHP schemes; electricity from renewable sources (except for hydro-power over 10 MW); supply of electricity to consumers with a climate change agreement (reduced rate).

In the UK fiscal year 2009-10, electricity was subject to a CCL rate of £4.70/MWh (HM Revenue and Customs (UK), 2010).

In order for suppliers of renewable electricity and good-quality CHP to qualify for exemption from the CCL, they must surrender levy exemption certificates (LECs). LECs are issued to accredited renewable electricity and CHP generators (by the UK Office of Gas and Electricity Markets (Ofgem)) for each MWh of electricity produced from renewable or CHP sources. The generators then sell these LECs to suppliers, who use them to claim exemption from the CCL for the supply of non-domestic electricity from renewable or CHP sources.

Estimating the subsidy equivalent

Differential taxes provide implicit subsidies to exempt sources of electricity. Under the CCL, exempt sources are electricity from renewables and good-quality CHP. Therefore, the production subsidy equivalent of the CCL is equal to the CCL rate per MWh, and the subsidy equivalent is the CCL rate per MWh multiplied by the 'induced' production of subsidised electricity.

Under the CCL, the amount of subsidised electricity is equal to the number of LECs created. The intrinsic value of a LEC is equivalent to the CCL on electricity (£4.70/MWh). This is the amount of the CCL that the supplier would have to charge the non-domestic consumer if the electricity were not exempted.

The estimation of the subsidy equivalent of the CCL was therefore similar to the estimation approach used to calculate the subsidy equivalent of renewable energy certificate schemes — the certificate price was multiplied by the number of certificates to estimate the subsidy equivalent (section J.4).

For the UK financial year 2009-10 (April 2009 to March 2010) 41 million LECs for electricity from renewable and CHP were issued to UK generators. This includes generation from renewable sources that existed prior to the commencement of the CCL in 2001, but does not include LECs issued to generators in neighbouring countries (about 18 per cent of LECs in 2009-10).[3]

The total value of CCL was therefore 41 million multiplied by £4.70/MWh, which was equal to £194 million (A$362 million). However, as noted above, a proportion of the LECs issued in 2009-10 were for generators that existed prior to the

[3] It also excludes LECs from Northern Ireland, which were not available separately for CHP and renenewables. Total LECs from Northern Ireland make up around 2 per cent of total UK LECs. Therefore their exclusion does not have a material effect on the Commission's estimates.

introduction of the CCL. For the estimation of the subsidy equivalent, this amount of generation has been excluded (table J.9).

Table J.9 **Renewable generation receiving LECs by technology[a,b]**
United Kingdom, April 2009 – March 2010

Technology	*Generation in 2009-10 receiving LECs*	*Generation in 2000*	*Additional generation in 2009-10*
	GWh	GWh	GWh
Biomass	3 190	487	2 703
Small hydroelectricity	568	214	354
Landfill gas	5 617	2 188	3 429
Municipal and industrial waste	1 163	840	323
Offshore wind	1 919	0	1 919
Onshore wind	6 815	946	5 869
Solar PV	0.3	0[c]	0.3
Sewage gas	696	367	329
Wave power	0.04	0	0.04
Total renewables	19 968	5 042	14 926

a Pre-existing generation includes total generation for each renewable technology — a small proportion of which may not have been eligible for the CCL exemption had it existed at the time. As such, it may represent an overestimate of the level of pre-existing generation, and as a consequence, 'additional' generation may be slightly underestimated. This is not expected to be significant. For example, in 2009-10, 19 968 GWh of renewable generation received LECs compared to a total of 20 558 GWh of renewable electricity generation. **b** The estimates of 'additional' generation in 2009 assume that for each renewable source, the amount of generation per unit of capacity installed in 2000 (the capacity factor) was the same as in 2009. **c** Only a small proportion of solar PV generation was provided with LECs in 2009-10 (0.337 GWh compared to generation of 20 GWh). Therefore the Commission has assumed that of the 1 GWh of solar PV generated in 2000 none would have been provided with a LEC.

Sources: Ofgem (UK) (2010a); DECC (UK) (2010a); Productivity Commission estimates.

For CHP, the Commission was unable to obtain information on the amount of CHP generation in 2000 that was 'good quality' and that would be eligible for the CCL exemption — as only total CHP data are available. Moreover, data from DECC (UK) (2010b) suggest that since 2000, electricity generation used for CHP has become more efficient. This is reflected in the decline in the heat to power ratio for CHP generation in the United Kingdom. Therefore, the Commission has used the following approach to estimate the amount of pre-existing good quality CHP:

- In 2009, there was 5.57 GW of installed CHP electrical capacity compared to 4.45 GW in 2000 (DECC (UK) 2010b). This suggests that 1.12 GW of additional CHP capacity was added over the time-frame in which the CCL has been in operation.
- In 2009, 5.57 GW of CHP capacity generated 27.7 TWh of electricity. This implies a capacity factor of 57 per cent. Based on this capacity factor, the

1.12 GW of additional CHP capacity contributed 5.6 TWh of CHP. This figure is likely to be an overestimate of the amount of additional CHP (for the purposes of the CCL analysis), as it does not distinguish between good quality CHP and other CHP.

- In 2009, 21.4 TWh of CHP electricity received LECs, out of a total of 27.8 TWh of CHP. This implies that 77 per cent of total CHP electricity was 'good quality'.
- Applying this proportion to the amount of additional CHP output in 2009 (5581 GWh) gives an estimate of additional good quality CHP in 2009 of 4.3 TWh.

Adding this amount of additional CHP to the estimate of additional renewable output from above gives an estimate of the total level of additional generation receiving the CCL exemption in 2009 of 19 TWh. Based on this level of generation, the subsidy equivalent of the CCL exemption was estimated to be £90 million (A$168 million) (table J.10).

Table J.10 **Subsidy equivalent, Climate Change Levy**
United Kingdom, April 2009 – March 2010

Variable	*Value*
Production subsidy (£/MWh)	4.70
New renewable generation (TWh)	14.9
New CHP generation (TWh)	4.3
Subsidy equivalent (excluding pre-existing renewables and CHP) (£m)	90
Subsidy equivalent (excluding pre-existing renewables and CHP) (A$m)	168

Sources: Ofgem (UK) (2010a; 2010b); Productivity Commission estimates.

Abatement

The Commission has not estimated abatement from the CCL scheme as a whole due to overlap between the CCL and the Renewables Obligation. For the renewable component of the CCL, almost all eligible renewable generation was covered by the Renewables Obligation. There are two exceptions:

- municipal waste and landfill gas installed since 2001
- additional renewable capacity installed in 2001 (prior to the introduction of the Renewables Obligation).

Abatement from these two components is estimated below. However, the Commission has not separately estimated the implicit abatement subsidy for this component of the CCL, as it was only a small component of total renewable

electricity covered under the CCL. Its effects are included in the average implicit abatement subsidy for the UK electricity generation sector as a whole.

CHP does not overlap with any other measures, hence abatement and the implicit abatement subsidy of CHP have been estimated.

Abatement from renewables

Municipal waste and landfill gas not covered by the Renewables Obligation, but covered by the CCL, was as follows (table J.11):

- 323 GWh of municipal and industrial waste (installed since 2001) was covered under the CCL, but not the Renewables Obligation.
- 1092 GWh of landfill gas (installed since 2001) was covered under the CCL, but not the Renewables Obligation.

Therefore, a total of 1.4 TWh of generation from these two sources was covered under the CCL estimates, but not the Renewable Obligation estimates.

In addition, Once large-scale hydroelectricity (which is not covered under the CCL), solar (which does not appear to be widely covered by the CCL) municipal waste and landfill gas (which have already been accounted for above) are excluded, an additional 301 GWh of renewable generation was generated in 2001 (of which 19 GWh was wind). It was assumed that this increase was as a result of capacity installed in 2001, and generates at the same level in 2009-10.

Therefore, a total of 1716 GWh of renewables are covered under the CCL, but not the Renewables Obligation. Using the counterfactual emissions intensity outlined in section J.3, abatement is estimated to be 959 kt CO_2 (table J.11).

Table J.11 **Renewables covered by the CCL**

United Kingdom, April 2009 – March 2010

	Units	*Renewable energy covered under the Renewables Obligation*	*Renewable energy exempted under the CCL*	*Renewables exempted under the CCL but not the Renewables Obligation*
Landfill gas	GWh	2 337	3 429	1 092
Municipal and industrial waste	GWh	0	323	323
Additional 2001	GWh	..	..	301
Total generation	GWh	..	..	1 716
Abatement	Mt CO_2	..	..	0.96

.. Not applicable.

Sources: Ofgem (UK) (2011a; 2011b); Productivity Commission estimates.

Abatement from good quality CHP

CHP captures the heat generated in the production of electricity and uses it for other productive purposes, such as heating, hot water or other industrial processes. Therefore, the abatement attributable to exempt CHP under the CCL was dependent on how much energy was saved through CHP and the emissions intensity of the source of energy that would otherwise have been used to generate heat. This was difficult to determine, as CHP uses a variety of fuels and technologies across a range of different applications, and as a consequence, displaces a range of fuels and technologies.

The DECC (UK) (2010a) provides various statistics on CHP in the United Kingdom. The Commission has used these statistics to derive estimates of abatement for the CHP component of the CCL exemption.

DECC (UK) (2010a) estimated that in 2009, CHP saved 9.5 Mt CO_2 in total or 1.7 Mt CO_2 per 1000 MW of installed capacity (p. 163). This implies an abatement factor of 0.34 t CO_2/MWh of electricity generated through CHP.[4]

Applying this abatement factor to the amount of additional CHP generation in 2009-10 gives abatement of 1.5 Mt CO_2 (table J.12).

Table J.12 **Abatement, Climate Change Levy (CHP)**
United Kingdom, April 2009 – March 2010

Variable	*Value*
Additional CHP generation	4.3 TWh
Abatement factor (t CO_2/MWh)	0.34
Abatement from CHP	1.5 Mt CO_2

Sources: Ofgem (UK) (2010a; 2010b); DECC (UK) (2010a; 2010c); Productivity Commission estimates.

Implicit abatement subsidy (CHP)

Based on the subsidy equivalent and abatement calculations above, the implicit abatement subsidy of the CCL was estimated to be £14/t CO_2 (A$26).

4 Calculated as follows: 1000 MW x 24 hours x 365 days x 57% (capacity factor) gives 4 984 440 MWh of output per year per 1000 MW of installed capacity. Based on this the DECC (UK) (2010a) figure can be expressed as 1.7 Mt of abatement per 4 984 440 MWh, which gives an abatement factor of 0.34t CO_2/MWh.

Sensitivity analysis

The Commission varied two key parameters to perform sensitivity analysis — the price of the LEC and the emissions intensity of the counterfactual source of electricity displaced by renewable electricity.

Alternative LEC price

LECs are not traded in a market, and as such it was not possible to observe a price. Rather, LECs are 'bundled' with electricity that is sold to suppliers by LEC-eligible generators. The Commission has based its estimates of the subsidy equivalent for this policy on the assumption that the value of a LEC was equal to the prevailing rate of the CCL. However, anecdotal evidence suggests that the implicit price that electricity suppliers pay for LECs was sometimes less than 100 per cent of the CCL rate. This could be because the purchasers (electricity retailers) have a degree of market power, or because of the transaction costs associated with purchasing and surrendering LECs.

To demonstrate the effects of this assumption on the final results, the Commission has carried out a sensitivity analysis using the assumption that the value of the LEC was 80 per cent of the rate of CCL for electricity (£3.76). Based on this LEC value, the subsidy equivalent of the CCL to renewable and CHP generators was £72 million (A$135 million), and the implicit abatement subsidy for CHP was estimated to be £11/t CO_2 (A$21).

Alternative abatement assumptions

For subsidised renewable electricity generation, two alternative counterfactual scenarios were considered.

The first assumes a higher emissions intensity of 0.69t CO_2/MWh based on Hawkes (2010). Using this higher emissions intensity, abatement from exempt renewables under the CCL was 1.2 Mt CO_2.

The second was based on the DECC (UK)(2010a) 'build margin' average emissions intensity of 0.39 t CO_2/MWh. Using this lower emissions intensity, abatement from exempt renewables under the CCL was estimated to be 669 kt CO_2.

Summary of estimates

Table J.13 provides a summary of the Commission's estimates of the subsidy equivalent, abatement, and implicit abatement subsidy for the CCL. These estimates imply an implicit abatement subsidy for CHP in the range of £11–£14/t CO_2 (A$21– A$26).

This range will be affected by future increases in the CCL rate. As of 1 April 2011, the CCL rate for electricity increased to £4.85/MWh. This will have the effect of increasing the value of the subsidy to exempt sources.

Table J.13 **Summary of estimates, Climate Change Levy**
United Kingdom, April 2009 – March 2010

	Units	*Low*	*'Central'*	*High*
Subsidy equivalent				
Renewables	£m	70	70	70
Renewables	A$m	131	131	131
CHP	£m	21	21	21
CHP	A$m	38	38	38
Abatement				
Renewables	Mt CO_2	0.7	1.0	1.2
CHP	Mt CO_2	1.5	1.5	1.5
Implicit abatement subsidy (CHP)	£/t CO_2	14	14	14
Implicit abatement subsidy (CHP)	A$/t CO_2	26	26	26
Alternative LEC price				
Implicit abatement subsidy (CHP)	£/t CO_2	11	11	11
Implicit abatement subsidy (CHP)	A$/t CO_2	21	21	21

Source: Productivity Commission estimates.

J.6 The Offshore Wind Capital Grants Scheme

The Offshore Wind Capital Grants Scheme offers an upfront grant of up to 40 per cent of the costs incurred over and above those that would be incurred from building a conventional power station. The scheme aims to contribute £107 million to the construction of offshore wind farms.

Many firms have recently repaid their capital subsidies from this scheme. This is because offshore wind farms are now eligible to receive two ROCs under the Renewables Obligation for every MWh they produce, and under European Union state aid rules, any wind farm that receives a capital subsidy is not eligible for the additional ROCs. A total of £49.6 million worth of grants were repaid, and are not

considered in the estimates (NAO (UK) 2010). (Note however, those that did not repay are still eligible to receive one ROC/MWh under the Renewables Obligation.)

Plants that received grants prior to July 2006 did not have the option of repaying the grant (BERR (UK) 2008). There appear to be four plants accredited prior to this date, that therefore have not repaid the grant. However, as these firms also receive a subsidy under the Renewables Obligation, abatement and an implicit abatement subsidy are not estimated for this scheme.

Estimating the subsidy equivalent

Each of the four plants subsidised received £10 million upfront — a total of £40 million in nominal terms. The four wind farms were commissioned in 2003, 2004, 2005 and 2006. While it was unclear when the grants were paid out, it was assumed that they were paid out in the year the plant was commissioned. Therefore, converting into 2010 currency, the subsidy provided by the scheme was £46.1 million.

Assuming an interest rate of 7 per cent, and an economic lifetime of 20 years, the annualised subsidy equivalent of the scheme was estimated to equal £4.3 million (A$8.1 million)

Sensitivity analysis

The subsidy equivalent was estimated using two alternate discount rates for annualising the capital subsidy:

- 11 per cent, which implies a subsidy equivalent of £5.8 million (A$10.8 million)
- 3 per cent, which implies a subsidy equivalent of £3.1 million (A$5.8 million).

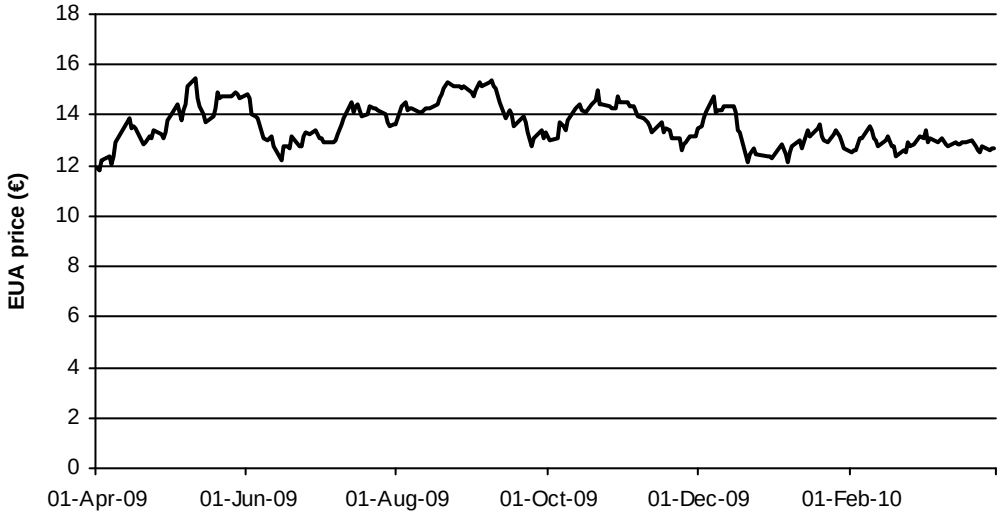
J.7 European Union Emissions Trading Scheme

Under the European Union ETS, electricity generators are obliged to surrender one European Union Allowance (EUA) for each tonne of CO_2 they emit. The total number of EUAs issued is capped at a level consistent with the EU target for EU-wide emissions reductions, and permits are traded in a market. Over the year 1 April 2009 to 31 March 2010, the average spot price of EUAs was €13.60

(£15.38), with a maximum daily settlement price of €15.50 (£13.70) and a minimum of €11.79 (£10.42) (figure J.4).[5]

Figure J.4 **EUA prices April 2009 to March 2010**

Weighted average daily settlement price (€) of the ECX EUA daily futures contract



Source: Frontier Economics (unpublished data).

The obligation to surrender EUAs increases the marginal costs of fossil-fuel generators. The increase in costs is proportional to the emissions intensity of electricity generation — coal-fired generators experience a larger increase in their marginal costs than gas generators because they are more emissions intensive. Through this effect on marginal costs, the European Union ETS effectively operates as a differential tax on electricity generators. Because gas-fired generators are taxed at a lower rate, they effectively receive a production subsidy equal to the difference between the effective 'tax rates' faced by coal and gas generators per MWh.

Using data on EUA prices and the average emissions intensity of coal- and gas-fired generators, the Commission has estimated that on average, the European Union ETS increased the marginal costs of coal-fired generators by £14.07/MWh, and gas-fired generators by £6.23/MWh (table J.14). This implies that the production subsidy equivalent to gas under the European Union ETS was £7.84/MWh.

5 Conversion based on the average exchange rate for April 2009 to March 2010 — €1 = £0.89.

Table J.14 **Parameter values — European Union ETS**

United Kingdom, April 2009 – March 2010

Parameter	*Notation*	*Value*	*Source*
Emissions intensity (t CO_2/MWh)			
Coal	a_c	0.915	DECC (UK) 2010a
Gas	a_g	0.405	
Average EUA price (2009-10)	p_{EUA}	€13.60 (£15.38)	Frontier Economics (unpublished data)
Average wholesale price of electricity (2009) (£/MWh)	p_1	34.70	Frontier Economics (unpublished data)
Total generation (2009) (GWh)			
Coal	q_c	104 608	DECC (UK) 2010a
Gas	q_g	165 482	DECC (UK) 2010a
Marginal cost increase (£/MWh)			
Coal	c_c	14.07	$c_c = a_c \cdot p_{EUA}$ = £14.07
Gas	c_g	6.23	$c_g = a_g \cdot p_{EUA}$ = £6.23

Sources: DECC (UK) 2010a; Frontier Economics (unpublished data); McGuinness and Ellerman (2008); Productivity Commission estimates.

Switching from coal to gas

Through the differential marginal cost increases, the European Union ETS gives electricity generators an incentive to switch from coal to gas. The existing literature provides some guidance on the extent of fuel switching. McGuinness and Ellerman (2008) analysed the effects of the European Union ETS on the UK electricity sector in 2005 and 2006, concluding that:

> … the CO_2 price did impact dispatch decisions, resulting in natural gas utilization that was from 19% to 24% higher and coal utilization that was 16% to 18% lower than would have otherwise occurred in 2005 and 2006. (McGuinness and Ellerman 2008, p. 1)

Between April 2005 and April 2006 (when the EUA price collapsed), the average price of EUAs was around €23. It is likely that this EUA price induced more fuel switching in 2005 and 2006 than in 2009-10, when the average was around €13.60. Hence, the Commission has assumed that the European Union ETS led to an increase in the use of gas of less than 20 per cent. The Commission's 'central' estimate is based on an assumption that the European Union ETS increased the use of gas by 10 per cent, compared to how much gas would have been used in the absence of the ETS. Other assumptions are tested in the sensitivity analysis.

Switching from coal to gas leads to abatement (because gas-fired electricity generation is less emissions intensive). For each MWh that was produced using gas rather than coal, the net reduction in emissions was given by the difference between the emissions intensity of coal and gas:

$a_c - a_g = 0.915 - 0.405 = 0.510$ t CO_2/MWh

Using data on the actual production of gas-fired electricity in 2009, it was possible to estimate the total amount of gas-fired generation that was induced by the European Union ETS (15 TWh) and the abatement attributable to the fuel switch (7.7 Mt CO_2) (table J.15).

The subsidy equivalent was equal to the implicit production subsidy to gas-fired generation (£7.84/MWh) multiplied by the total increase in gas-fired generation, and was estimated to be £118 million (A$220 million).

The implicit abatement subsidy is the subsidy equivalent divided by abatement attributable to the ETS, and is equal to the EUA price (A$28.64/t CO_2 in the year of analysis).

Table J.15 **European Union ETS-induced gas-fired generation, abatement and subsidy equivalent**[a]

United Kingdom, April 2009 – March 2010

	Calculation	*Value*
Total gas generation 2009	*g*	165 TWh
Total gas generation induced by the EU ETS	*qg = g – (g / 1.10)*	15 TWh
Abatement	*A = qg · (ac – ag)*	7.7 Mt CO_2
Subsidy equivalent[b]	*TSE = qg · 106 · £7.84*	£118m (A$220m)

a Assuming that the European Union ETS led to an increase of 10 per cent in the use of gas in 2009-10. **b** The quantity of gas induced by the ETS was multiplied by 10 million because generation is in TWh and the production subsidy equivalent is in £/MWh.

Sources: DECC (UK) 2010a, Productivity Commission estimates.

Sensitivity analysis

The Commission's estimate of the subsidy equivalent to gas-fired generators was based on the assumption that the European Union ETS increased the use of gas-fired generation by 10 per cent in 2009-10. This assumption was based on the limited academic literature on the subject (McGuinness and Ellerman 2008). Estimates of abatement and subsidy equivalent are sensitive to changes in this parameter (table J.16).

Table J.16 **Sensitivity analysis — European Union ETS-induced gas-fired generation**

United Kingdom, April 2009 – March 2010

Increase in gas-fired generation attributable to European Union ETS	*Induced generation*	*Subsidy equivalent (UK pounds)*	*Subsidy equivalent (Australian dollars)*	*Abatement*
%	TWh	£m	A$m	Mt CO_2
0	0	0	0	0
5	7.8	62	115	4
10	15.0	118	220	7.7
15	21.5	169	315	11
20	27.6	216	403	14

Source: Productivity Commission estimates.

The interaction of the European Union ETS with other policies

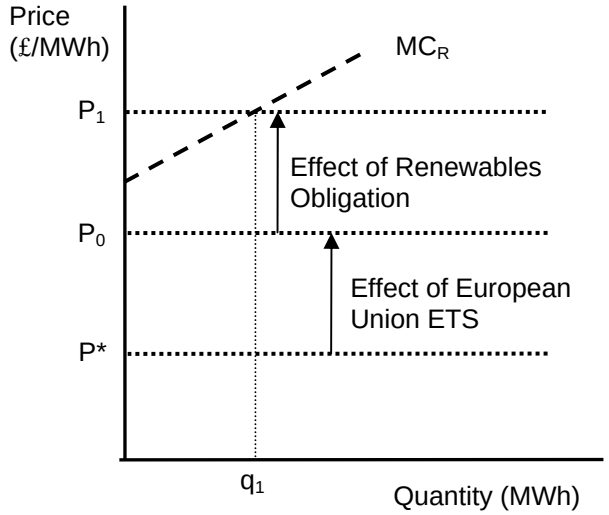
The Commission's analysis of the European Union ETS has focused on the effect of the ETS on the mix of coal- and gas-fired generation. The estimates of the subsidy equivalent and abatement arising from the European Union ETS in the United Kingdom relate exclusively to this effect. However, the European Union ETS also has other effects, and interacts with other policies that the Commission has assessed. In particular:

- the European Union ETS provides a subsidy to renewables that was in addition to the subsidies delivered through other analysed policies
- the existence of the European Union ETS is relevant when considering the net abatement brought about by the other policies.

Subsidy equivalent effects

As well as the implicit subsidy to gas-fired generators during some periods, the ETS also delivers an effective subsidy to other low-emissions generators, by increasing the average wholesale price of electricity more than it increases their costs. This is illustrated in figure J.5, using the example of the Renewables Obligation. In the absence of any policy intervention, the wholesale price of electricity would be P*. At this level, renewables would not be used, because the marginal cost of renewables (MC_R) exceeds the wholesale price of electricity. The introduction of the European Union ETS increases the wholesale price of electricity to P_0, and Renewables Obligation certificates provide an additional incentive, and increase the effective price received by renewables to P_1. At this price, output from renewables will equal q_1.

Figure J.5 **Interaction of the European Union ETS and the Renewables Obligation**



The Commission's analysis of the Renewables Obligation, CCL, and the Offshore Wind Capital Grants Scheme was based on the assumption that the counterfactual price of electricity that would have been received in the absence of the policies was equal to the 2009-10 average wholesale electricity price (in figure J.5 this is P_0). However, renewables also receive an additional effective subsidy arising from the wholesale electricity price uplift that results from the European Union ETS (raising the price from p* to p_0).

Estimating what the wholesale electricity price would be in the absence of the European Union ETS is complicated because the effects of the ETS on electricity markets vary during the year. Specifically, if the marginal generator was gas-fired, the wholesale price uplift would be equal to the marginal cost uplift faced by gas-fired generators. If the marginal generator was coal-fired the wholesale price uplift would be equal to the marginal cost uplift fact by coal-fired generators.

The average wholesale electricity price uplift over the course of the year can be estimated using the average emissions intensity of the marginal generator over the year. Frontier Economics stated that the average emissions intensity of the marginal generator in the United Kingdom in 2009-10 was 0.565 t CO_2/MWh. This is consistent with the marginal generator being gas approximately two-thirds of the time, and coal approximately one-third of the time.

Given an average EUA price of £15.38, the average wholesale price uplift attributable to the European Union ETS was £8.69/MWh. This suggests that for every MWh of electricity induced by the Renewables Obligation, CCL and the

Offshore Wind Capital Grants Scheme, the operators of these facilities received an additional subsidy with an average value of £8.69.

In estimating the value of the subsidy equivalent arising from the European Union ETS, it is important to note that each unit of electricity can receive this subsidy only once. There are significant overlaps in the Renewables Obligation, CCL and the Offshore Wind Grants Scheme:

- Electricity that was produced by offshore wind farms also received ROCs. To avoid double counting, the electricity generated by offshore wind farms has only been credited against the Renewables Obligation. Hence, the interaction of the European Union ETS and the Offshore Wind Capital Grants program was estimated to be zero.
- Most generators that receive a CCL exemption also received ROCs (section J.5 estimates the total additional generation arising from the CCL exemption).

The Commission has estimated that the additional subsidy equivalent that should be attributed to these policies was around £150 million (A$278 million) (table J.17).

Table J.17 **European Union ETS, interaction with other policies**
United Kingdom, April 2009 – March 2010

		Subsidy equivalent from European Union ETS	
Policy name	*Generation induced*	*UK pounds*	*Australian dollars*
	TWh	£m	A$m
Renewables Obligation	15.5	135	251
Climate Change Levy	1.7	15	27
Offshore Wind Capital Grants Scheme	0	0	0
Total	17.2	150	278

Source: Productivity Commission estimates.

Abatement effects

The European Union ETS places a cap on the total greenhouse gas emissions from electricity generation and a range of industrial sectors in 30 countries. The advantage of using an ETS to achieve a given emissions-reduction target is that it creates incentives for firms to seek out the least-cost options for abatement. Alternative policies generally operate by mandating or giving preference to particular technologies (such as renewable energy). While such policies may be

successful in meeting the target for emissions reductions, generally the cost of achieving a given level of abatement is higher.

The three other policies analysed for the United Kingdom (the Renewables Obligation, CCL and the Offshore Wind Capital Grants Scheme) all have the effect of providing effective subsidies to renewable energy. The renewables offset some fossil-fuel generation, leading to emissions reductions. However, given that the United Kingdom is a member of the European Union ETS, the net effect of these policies is to induce no additional emissions reductions across the EU as a whole. The policies might lead to abatement in the UK electricity sector, but this will be offset by higher emissions in other sectors and other countries (because the emissions cap is binding at the EU-wide level).

Effectively, these policies 'carve out' a portion of the emissions-reduction target and reserve it for particular technologies. Inevitably, this results in an over-supply of higher-cost abatement options (chapter 3). As well as not providing any additional net abatement, these policies increase the costs of meeting a given emissions-reduction target. As the Commission has stated previously:

> Reserving a proportion of electricity generation for renewable energy sources changes the generation mix in a way that increases abatement costs for no additional emissions reduction benefit. (PC 2008, p. xvii)

The Commission's estimates of the abatement attributable to the policies and the implicit abatement subsidies give an indication of the relative efficiency of each policy in achieving a given emissions -reduction target. The European Union ETS leads to a significant amount of relatively low-cost abatement (around 7.7 Mt at an implicit abatement subsidy of around A$29/t CO_2). The Renewables Obligation leads to a similar amount of abatement at around six times the cost (8.9 Mt at an implicit abatement subsidy of around A$176/t CO_2).

J.8 Feed-in Tariffs

The United Kingdom introduced a FIT scheme for Great Britain in April 2010 (the scheme does not apply in Northern Ireland). The first year of the scheme concluded on 31 March 2011. Feed-in tariffs apply to small -scale renewable generation that is less than five MW capacity.

The Commission has not included the FIT scheme in its estimates of the subsidy equivalent for emissions-reduction policies in the United Kingdom for two reasons. The first is that the Commission chose to analyse UK policies for the 2009-10 financial year. This decision was made because data for the 2010-11 year were

unlikely to be available in time to carry out a thorough analysis. Given the start date of the FIT scheme, it was not possible to include the FITs in the detailed analysis. Second, many of the installations that are eligible to receive FITs had been eligible to receive certificates under the Renewables Obligation in 2009-10. The Commission has estimated the subsidy equivalent and abatement attributable to the Renewables Obligation in 2009-10. When the FIT scheme commenced, installations were transferred out of the Renewables Obligation and into the FIT scheme. While it might have been possible to estimate the subsidy equivalent of the FITs (using a number of assumptions), aggregating the effects of the FITs in 2010-11 with the effects of the Renewables Obligation in 2009-10 would lead to double-counting of the abatement attributable to these installations. Instead of estimating the subsidy equivalent and abatement attributable to the FITs, the Commission provides some background information on the scheme.

Estimating the subsidy equivalent

Under the FIT scheme, electricity generated from hydroelectricity power, wind, solar PV, anaerobic digestion and micro CHP pilot plants receive FITs. Rates vary by technology and by the size of installations (smaller plants receive higher tariffs) (Ofgem (UK) 2010d). Based on the average 'system sell price' of electricity, it was possible to estimate the production subsidy equivalent ($\square_i$) arising from the FITs (table J.18).

There are currently no data available on the quantity of electricity that received the FITs. However, the Commission has accessed data on the total payments made under the FIT scheme. For the first nine months of the scheme (to 31 December 2010), total payments were £6.2 million (approximately A$10.4 million) (Ofgem (UK) 2010d; 2010e; 2011a). Data on the number of installations registered to receive FITs suggest that this number would be expected to increase in 2011-12.

Implicit abatement subsidy

The Commission has estimated the implicit abatement subsidy for each technology that was eligible to receive FITs based on the estimated emissions counterfactuals supplied by Frontier Economics. The Commission's estimates (table J.18) suggest that the implicit abatement subsidy through the FITs will be significantly larger for some technologies than others. In particular, small wind and solar PV installations will receive very large implicit abatement subsidies. This is consistent with the estimates of implicit abatement subsidies provided by FITs for these technologies in other countries.

Table J.18 **Implicit abatement subsidy, Feed-in Tariffs**
United Kingdom, April 2010 – March 2011

Technology	*FIT*	*Production subsidy equivalent*	*Counterfactual emissions*	*Implicit abatement subsidy*[a]	
				UK pounds	*Australian dollars*
	pence/kWh	pence/kWh	t CO_2/MWh	£/t CO_2	A$/t CO_2
Hydroelectricity	4.5–19.9	0.8–16.2	0.565	14–287	24–481
Wind	4.5–34.5	0.8–30.8	0.587	14–545	24–914
PV	29.3–41.3	25.6–37.6	0.61	453–665	760–1 116
MicroCHP pilot	10	6.3	0.565	112	187
Anaerobic digestion	9–11.5	5.3–7.8	0.565	94–138	157–232
Existing microgenerators transferred from the RO	9	5.3	0.565	94	157

[a] Based on a conversion factor of £0.60 per $A (2010).

Sources: Ofgem (UK) (2010c); Frontier Economics (unpublished data); Productivity Commission estimates.

The UK FIT system operates as a gross FIT scheme, with additional subsidies for electricity exported. For electricity generated and consumed on the premises, generators receive the FIT. For electricity exported to the grid, generators receive the relevant FIT, and an additional tariff of £0.03/kWh. In the initial period of the FIT scheme, the percentage of electricity that was exported to the grid was 'deemed' by the regulator to be 50 per cent for wind, solar and CHP, and 75 per cent for hydroelectricity and anaerobic digestion.

The effect of the deemed export tariff was to increase the production subsidy equivalent by an average of £0.015/kWh for wind, solar and CHP, and £0.0225/kWh for hydroelectricity and anaerobic digestion. This would raise the implicit abatement subsidy for each source.

J.9 Summary

Based on the subsidy equivalent and abatement estimates for each policy outlined in the sections above, the UK electricity generation sector total subsidy equivalent, total abatement and average implicit abatement subsidy can be estimated. This section outlines the approach taken to calculate these estimates.

The total subsidy equivalent

The total subsidy equivalents estimated represent the total value of the subsidy granted to low-emissions generation that was 'induced' by each policy. These can be added together, to give an estimate of the total subsidy equivalent for the UK electricity sector. The estimates implied a range for the total subsidy equivalent of between £1.1 billion and £1.3 billion (A$2 billion and A$2.4 billion) (table J.19). This represented between 0.08 and 0.10 per cent of UK GDP.

Table J.19 **Total subsidy equivalent[a]**

United Kingdom, April 2009 – March 2010

	Total subsidy equivalent (UK pounds)			*Total subsidy equivalent (Australian dollars)*		
Policy	*'Central'*	*High*	*Low*	*'Central'*	*High*	*Low*
	£m	£m	£m	A$m	A$m	A$m
European Union ETS — coal/gas switch	118	216	62	220	403	115
Renewables Obligation						
Certificates	845	845	810	1 573	1 573	1 508
Effects of the European Union ETS	135	135	135	251	251	251
Climate Change Levy						
LEC exemptions	90	90	72	168	168	135
Effects of the EU ETS	15	15	15	27	27	27
Offshore Wind Capital Grant Scheme	4	6	3	8	11	6
Total	1 207	1 307	1 096	2 247	2 433	2 042

a High — the highest subsidy equivalent estimated under sensitivity analysis. Low — the lowest subsidy equivalent estimated under sensitivity analysis. No sensitivity analysis has been carried out for the estimates of the effects of the European Union ETS on the policies to encourage the use of renewables.

Source: Productivity Commission estimates.

Total abatement

Added together, the estimate of the total abatement in the UK electricity sector due to the policies analysed was between 12.3 Mt and 27.4 Mt of CO_2 (table J.20). This represented between 8 and 15 per cent of UK counterfactual electricity sector emissions in 2009.

Table J.20 **Total abatement in the UK electricity sector[a]**

United Kingdom, April 2009 – March 2010

	Total abatement		
Policy	*'Central'*	*High*	*Low*
	Mt CO_2	Mt CO_2	Mt CO_2
EU ETS	8	14	4
Climate Change Levy (renewables)	1	1	1
Climate Change Levy (CHP)	2	2	2
Renewables Obligation	9	11	6
Total	19	27	12

a High — the highest abatement estimated under sensitivity analysis. Low — the lowest abatement estimated under sensitivity analysis.

Source: Productivity Commission estimates.

Average implicit abatement subsidies

Using the above estimates, a range of sector-wide average implicit abatement subsidy estimates can be calculated for the United Kingdom (table J.21). Depending on the assumptions used, these ranged from £40–£107/t CO_2 (A$75–A$198).

Table J.21 **Average implicit abatement subsidy**

United Kingdom, April 2009 – March 2010

	Implicit abatement subsidy (UK pounds)			*Implicit abatement subsidy (Australian dollars)*		
Total subsidy equivalent scenario	*'Central' abatement*	*High abatement*	*Low abatement*	*'Central' abatement*	*High abatement*	*Low abatement*
	£/t CO_2	£/t CO_2	£/t CO_2	A$/t CO_2	A$/t CO_2	A$/t CO_2
'Central'	63	44	98	118	82	183
High	69	48	107	128	89	198
Low	58	40	89	107	75	167

Source: Productivity Commission estimates.

In addition, given the overlaps discussed in section J.4, it was possible to estimate an implicit abatement subsidy for the renewable generation induced by all UK policies separately. The subsidy equivalent is the sum of the renewable component of the CCL and the European Union ETS, plus the subsidy equivalent of the Offshore Wind Capital Grants scheme and the Renewables Obligation. This was estimated to be between £1 billion and £1.1 billion (A$1.9 billion and A$2 billion), with a 'central' estimate of £1.07 billion (A$1.99 billion).

Abatement was the sum of the Renewables Obligation abatement, plus the additional abatement attributed to the renewables component of the CCL. This was estimated to be between 7 Mt CO_2 and 12 Mt CO_2, with a 'central' estimate of 10 Mt.

Therefore, the implicit abatement subsidy of renewables generation in the United Kingdom was estimated to be between £86–£158/t CO_2 (A$160–A$294), with a 'central' estimate of £108/t CO_2 (A$201).

J.10 Other UK electricity generation policies

The Commission's analysis is based on a subset of the emissions reduction measures that apply in the UK electricity generation sector. While these measures are considered to represent a large proportion of the total subsidy equivalent (and associated abatement) applicable in the United Kingdom, they do not reflect the entire suite of measures that are in place. Moreover, some recently committed measures will have implications for future analyses of implicit abatement subsidies.

Excluded policies

The Commission identified a number of electricity sector measures in the United Kingdom that were not included in the preceding analysis as they did not meet the Commission's criteria for policy inclusion. These policies include:

- the Energy Crops Scheme (UK) — subsidies to farmers for the establishment of crops for use in CHP
- Carbon Capture and Storage readiness (UK) — requirement for all new coal-fired power stations over 300 MW in capacity to be carbon capture and storage ready
- reduced VAT for energy saving materials and micro-generation (UK) — reduced VAT rate of 5 per cent (compared to 20 per cent) for micro-generation
- various community-based programs, including:
  - Ynni'r Fro (Wales) — capital subsidies for community-based renewable projects
  - Arbed (Wales) — direct government investment in low-income communities focusing on renewable energy programs (among other things)
  - Community and Renewable Energy Scheme (Scotland) — subsidies to community organisations (such as schools) for renewable technologies.

Individually, these policies were not considered likely to have provided a material subsidy equivalent for lower -emissions technologies, relative to the policies for which subsidy equivalents were estimated. Nor where they considered to have contributed significant amounts of abatement relative to the policies for which abatement was estimated — either as a result of limited coverage or budget. However, combined, it is possible that these measures could have a small influence on the Commission's estimate of the total subsidy equivalent and total abatement for the United Kingdom.

Committed policies

The Commission's analysis for the United Kingdom was undertaken for the financial year 2009-10. As such, it excluded a number of policies that have been committed for future implementation by the UK Government. In particular, the 2011 UK Budget announced the introduction of a carbon price floor for electricity generation.

Carbon price floor

From 1 April 2013, a carbon price floor for electricity generation will be introduced. The carbon price floor will start at around £16/t CO_2 and follow a linear path to £30/t CO_2 in 2020 (HM Treasury (UK) 2011a). The UK Government has indicated that it will adopt the following measures to achieve the carbon price floor:

- A carbon price support rate — the difference between the Government's carbon price (the floor) and the futures market price for carbon under the European Union ETS in 2013. The tax rate will be equivalent to £4.94/t CO_2 in 2013-14.
- The carbon price floor will be given affect through changes to the CCL and fuel duty. From April 2013, suppliers of fossil fuels used in electricity generation will become liable either for the CCL or fuel duty — suppliers will be charged the relevant carbon price support rate based on the average carbon content of each fossil fuel. Currently, these supplies are exempt from the CCL.
- Fossil fuels used to generate electricity in a CHP plant will be liable for reduced carbon price support rates of CCL and fuel duty.
- The existing rates of CCL will be retained.

Further details on the carbon price floor are expected to be available in consultation legislation in the second half of 2011 (HM Treasury (UK) 2011b).

Where the price floor is binding, the effect would be to increase the subsidy equivalent for renewable sources exempt under the CCL. The removal of the exemption for fossil fuels used to generate electricity (including in a CHP plant) has the effect of imposing a new fossil fuel tax. This would be considered as a new and additional policy to the suite of measures estimated by the Commission.

K The United States' electricity generation sector

The Commission estimated subsidy equivalents, abatement and implicit abatement subsidies for several US policies, including the Regional Greenhouse Gas Initiative, state-based Renewable Portfolio Standards, the Renewable Electricity Production Tax Credit and Section 1603 Treasury Grants. Four Californian capital subsidies (the Californian Solar Initiative, New Solar Homes Partnership, Self-Generation Incentive Program and the Emerging Renewables Program) were also examined. These Californian schemes have been included as California is responsible for approximately 70 per cent of US solar generation, which is not included in the federal-level policies analysed.

Several other policies were considered, but not included in the estimates (section K.15). In particular, the Commission's analysis of state-based schemes was restricted due to constraints of time and data availability. For some federal schemes, the Commission was not able to obtain the data necessary to estimate abatement.

Where data permitted, subsidy equivalents and abatement were estimated for the 2010 calendar year. However, for many schemes, the year of analysis was 2009. Subsidy equivalents and implicit abatement subsidies are reported in both US and Australian dollars, with currency conversion rates based on the average exchange rate for 2010 (A$/US$ = 1.087). A GDP deflator of 1.01 was used to convert 2009 values into 2010 values.

For some of the policies that were analysed in detail, the Commission carried out sensitivity analysis. The results of the sensitivity analysis are reported in comparison to the Commission's 'central' estimate. The central estimate is based on the set of assumptions that the Commission considers to be most consistent with its approach to estimating subsidy equivalents and abatement.

References in this appendix to Vivid Economics refer to unpublished data supplied to the Productivity Commission by that contractor. The relevant data are provided on the Commission's website, where there are no commercial-in-confidence restrictions.

K.1 Electricity generation in the United States

This section outlines some of the key features of the US electricity market, followed by some key statistics for the US electricity generation sector.

The structure of the US electricity market

There are three loosely-connected electricity grids in the United States (the Western Interconnected System, the Eastern Interconnected System, and the Texas Interconnected System)[1] and ten electricity markets (box K.1). The US electricity system is also integrated with Canada and, to a lesser extent, Mexico (table K.1).

Table K.1 **Imports and exports of electricity**
United States, 2009

	Imports	*Exports*
	TWh	TWh
Canada	51	17
Mexico	1	0.6

Source: EIA (US) (2011g).

Traditionally, US electricity markets were operated by vertically-integrated utilities that owned and operated the transmission networks. Markets were formed via agreements between the utilities (for example, the PJM Interconnection was formed by an agreement between three utilities in 1927, and was traditionally operated by one of these utilities (PJM 2011)).

Since the late 1990s, many of the participants in these markets have formed an Independent System Operator (ISO) or a Regional Transmission Organisation (RTO). Seven markets (California, Midwest, New England, New York, the PJM, the Southwest Power Pool (SPP) and Texas) now have an ISO or RTO. ISOs and RTOs operate the transmission networks and coordinate competitive wholesale markets, with electricity provided via either long-term contracts or short-term (day ahead) markets. The equilibrium price is generally determined by the bid of the marginal generator (Linn 2011).

In markets without an RTO or ISO, vertically-integrated utilities operate the transmission networks and make investment decisions subject to the approval of the

1 There are a total of eight 'ties' between the three grids, which permit limited electricity transfers between the grids (Kaplan 2010).

state regulator. Similarly to a wholesale market, electricity from generators in these markets is dispatched in order of increasing cost (Linn 2011).

Box K.1 US electricity markets

There are ten US electricity markets operating across the three electricity grids. Peak demand data is shown for the most recent year available.

Western Interconnection

- California — covering most of California (summer peak demand — 46 GW (2009))
- Northwest — covering most of Washington, Oregon, Idaho, Utah, Nevada, Montana, Wyoming and part of California (summer peak demand — 44 GW (2009))
- Southwest — covering most of Arizona, New Mexico and Colorado, and parts of Nevada, Wyoming and South Dakota (peak demand — 45 GW (2005))

Eastern Interconnection

- Midwest — covering most of North Dakota, South Dakota, Nebraska, Minnesota, Iowa, Wisconsin, Illinois, Indiana and Michigan, and parts of Montana, Missouri, Kentucky and Ohio (summer peak demand — 116 GW (2006))
- New England — covering Connecticut, Massachusetts, New Hampshire, Rhode Island and Vermont (summer peak demand — 25 GW (2009))
- New York (summer peak demand — 30 GW (2009))
- PJM Interconnection — covering most of Delaware, District of Columbia, Maryland, New Jersey, Ohio, Pennsylvania, Virginia and West Virginia, and parts of Indiana, Illinois, Kentucky, Michigan, North Carolina and Tennessee (summer peak demand — 127 GW (2009))
- Southeast — covering most of Florida, Arkansas, Louisiana, Mississippi, Alabama, Tennessee, North Carolina, South Carolina and parts of Missouri, Texas and Kentucky (summer peak demand — 195 GW (2009))
- Southwest Power Pool (SPP) — covering most of Kansas, Oklahoma and Nebraska and parts of New Mexico, Texas, Louisiana, Missouri, Mississippi and Arkansas (summer peak demand — 43 GW (2008))

Texas Interconnection

- Texas — covering most of Texas (summer peak demand — 63 GW (2009)).

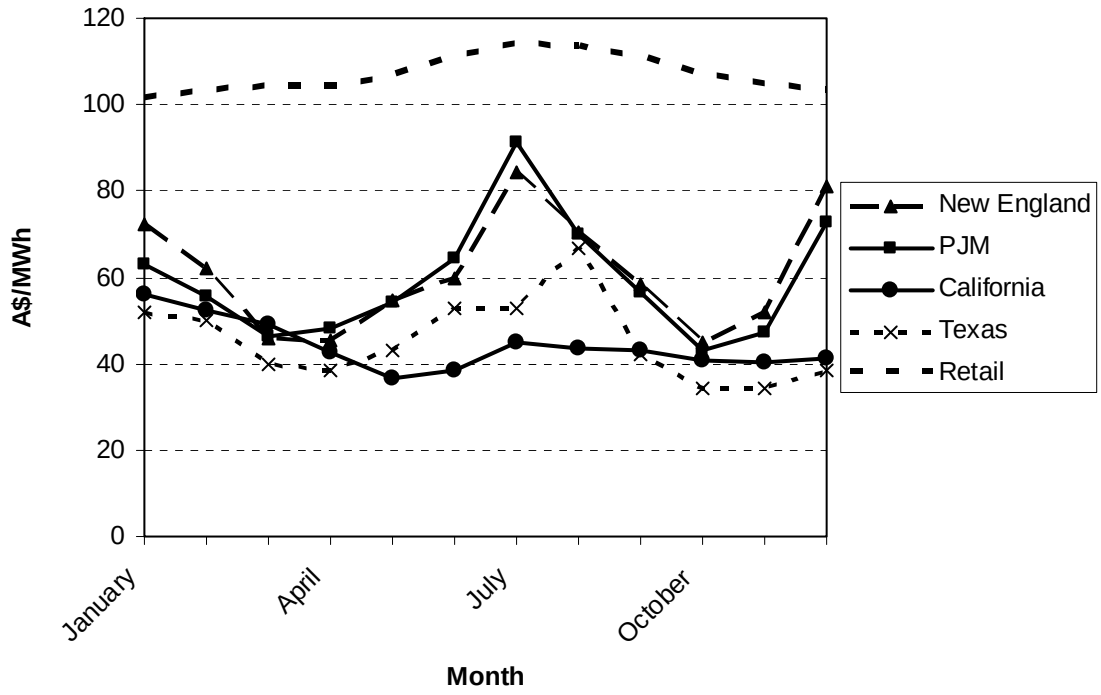
Source: FERC (2011).

Key statistics

Electricity prices

Wholesale prices in the United States vary across each market. Across four markets selected by the Commission, the average wholesale price in 2010 varied from US$41/MWh (A$44) in California to US$56/MWh (A$61) in New England) (figure K.1). The average retail price across all US markets in 2010 was approximately US$99/MWh (A$107).

Figure K.1 **Wholesale and retail electricity prices[a]**
United States, 2010



a Data for New England, PJM, California and Texas are wholesale prices based on unweighted average daily prices from a selected exchange in each market. Retail is the average US retail price.

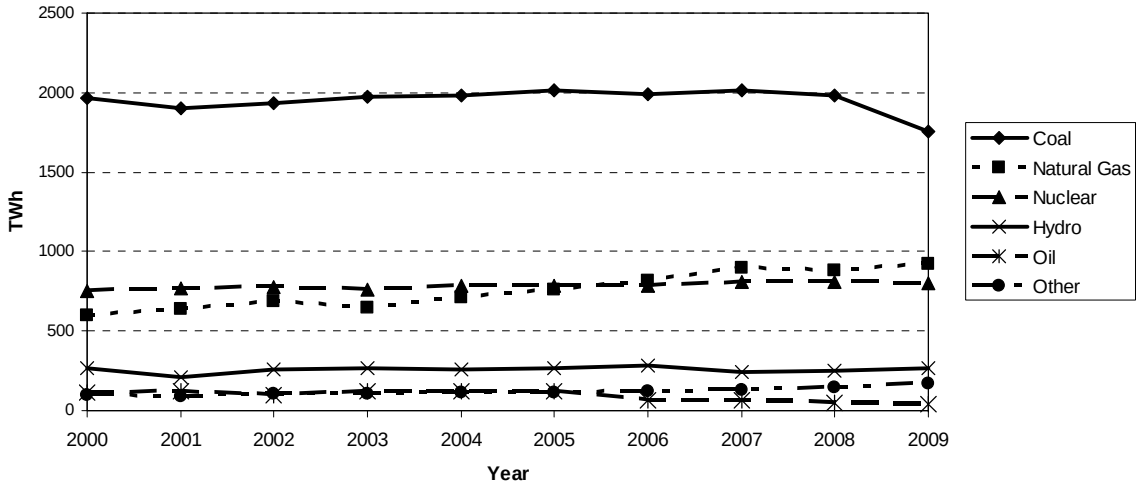
Sources: EIA (US) (2011e 2011o).

Electricity generation

The US electricity generation sector is predominantly a mix of coal, natural gas and nuclear (figure K.2). Renewable energy sources are currently a small but increasing component of the US generation mix. The primary source of non-hydro renewable energy used in electricity generation in the United States in 2009 was wind

(table K.2). Biomass and geothermal were also major sources of renewable electricity. Total generation in the US in 2009 was around 3950 TWh (EIA (US) 2010e).

Figure K.2 **Electricity generation by source**
United States, 2000–2009



a 'Other' predominantly consists of renewable electricity.

Source: EIA (US) (2011m).

Table K.2 **Non-hydro renewable energy sources**
United States, 2009

Renewable energy source	*Generation*
	GWh
Wind	73 886
Wood and wood derived fuels	35 596
Other biomass	18 443
Geothermal	15 009
Solar thermal and photovoltaic	891

Source: EIA (US) (2011m).

Greenhouse gas emissions

In 2009, the US electricity generation sector emitted 2270 Mt CO_2. This was lower than the peak of 2547 Mt CO_2 in 2007 (EIA (US) 2011h). In 2008, 81 per cent of electricity sector emissions were from coal-fired generation, 17 per cent were from natural gas, and the remaining 2 per cent were from other sources such as oil.

K.2 Abatement

Abatement in the United States was estimated using counterfactual emissions intensities for each electricity market. The counterfactual emissions intensities used were based on data provided by Vivid Economics (2011), which are in turn based on annual reports that each grid's operator makes to the Federal Energy Regulatory Commission. In most cases, the marginal generator (the generator that is next in the dispatch order) varies over the course of the year (for example, sometimes coal is the marginal energy source and sometimes gas is). Where this is the case, the grid marginal emissions intensity is estimated as an average of the emissions intensities of the marginal sources, weighted according to the proportion of time that each is marginal. These emissions intensities range from 0.406 t CO_2/MWh for California, to 0.908 t CO_2/MWh for the Midwest (table K.3).

Table K.3 **Grid marginal emissions intensities**
United States

Grid	*Marginal source*	*Marginal emissions intensity*
		t CO_2/MWh
California	Gas	0.406
Midwest	Coal (73 per cent) and gas (27 per cent)	0.908
New England	Gas (67 per cent), coal (18 per cent) and hydro pumped storage (15 per cent)	0.600
New York	Gas	0.597
PJM	Coal (80 per cent) and gas (20 per cent)	0.792
SPP	Coal (62 per cent) and gas (38 per cent)	0.795
Texas	Gas (73 per cent), coal (22 per cent) and wind (5 per cent)	0.600
Northwest	Gas	0.473
Southwest	Gas	0.468
Southeast	Coal and Gas[a]	0.770

a For the Southeast grid, proportions of the time each source was the marginal generator were not available, so it was assumed that each source is the marginal generator 50 per cent of the time.

Source: Vivid Economics 2011.

K.3 Policy overlaps

The Commission estimated the subsidy equivalent and abatement attributable to: state-based Renewable Portfolio Standards; the federal Renewable Electricity Production Tax Credit; Section 1603 Treasury Grants (federal); and four Californian capital subsidies (the Californian Solar Initiative, New Solar Homes Partnership, Self-Generation Incentive Program and the Emerging Renewables Program).

Renewable generators subsidised by the state-based Renewable Portfolio Standards are also eligible for subsidies under the Renewable Electricity Production Tax Credit or the Treasury Grants. Hence, these programs are considered to overlap completely. For this reason, the Commission has estimated:

- the abatement attributable to the Renewable Portfolio Standards and the two federal schemes in aggregate
- the combined implicit abatement subsidy attributable to these policies.

In estimating abatement from the state-based Renewable Portfolio Standards and the two federal level programs, the Commission has not made an assumption as to which of these policies is the 'binding' policy. Rather, it was assumed that the three programs in combination provided incentives for the development of eligible renewable energy generation. This is discussed further in section K.8.

The federal schemes do not cover solar photovoltaic (PV). For this reason, the Californian capital subsidies were assumed to not overlap with the federal schemes. Therefore, the Commission has separately estimated the abatement attributable to the set of Californian capital subsidies.

K.4 The Regional Greenhouse Gas Initiative

The Regional Greenhouse Gas Initiative (RGGI) is a state-based cap-and-trade emissions trading scheme covering the electricity sectors of 10 US states (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont). In 2009, these states accounted for approximately 9 per cent of US electricity generation. The scheme commenced in 2009, and aims to reduce CO_2 emissions from these ten electricity sectors by 10 per cent by 2018 relative to 2009 levels.

Generators larger than 25 MW in the participating states must purchase an allowance for every US (short) ton of CO_2 emissions (one short ton = 0.907 metric tonnes). These allowances must be surrendered every three years (the first compliance period ends at the end of 2011). Generators can use permits issued by any of the ten states for compliance. Quarterly auctions are held to distribute allowances.

The cap has been set to initially stabilise emissions in the participating states at 188 million US (short) tons. The cap will remain at this level from 2009 to 2014, before declining by 2.5 per cent per year until 2018. It appears that this cap is not binding, and therefore probably not leading to any reduction in emissions. The New York State Energy Research and Development Authority (NYSERDA) stated:

> CO_2 emissions in the RGGI region have declined from approximately 184.4 million [US (short)] tons in 2005 to 123.7 million [US (short)] tons in 2009, or 33 percent. (NYSERDA 2010b, p. 3)

NYSERDA identified three reasons why emissions fell, lower demand for electricity, increased use of gas in place of coal (due to relatively low gas prices), and changes in the available capacity.

The assertion that the cap is not binding is supported by the price of permits in the scheme. The auction reserve price (effectively a minimum permit price) for RGGI permits was set at US$1.86 (A$2.05) per US (short) ton in 2010 (equivalent to US$2.05 per (metric) tonne CO_2 (A$2.3)). For much of 2010, the permit price was very close to this level — trading from US$2.28 per (metric) tonne CO_2 (A$2.50) in March, to US$2.07 per (metric) tonne CO_2 (A$2.30) in June, and falling to the reserve price thereafter (Potomac Economics 2011).

The Commission's analysis of supply-side abatement due to emissions trading schemes focuses on fuel switching, such as the switch from coal to gas in the United Kingdom and Germany. At the 2010 permit price, the Commission considers it unlikely that much, if any, fuel switching is occurring due to the RGGI (box K.2). There may be a small increase in electricity prices, and thus some demand-side abatement (considered in section 4.4). However, for the supply-side analysis, the Commission estimated that the subsidy equivalent and abatement arising from the RGGI is zero. This is consistent with Linn (2011), who stated that:

> The RGGI permit price has been close to the minimum bid since mid 2010 … This implies that abatement because of the cap is very close to zero. (Linn 2011, p. 16).

As the RGGI cap begins to tighten, it is likely that the permit price will rise, and this may lead to some fuel switching and supply-side abatement within the electricity sector of the relevant states.

The United States has another state-based emissions trading scheme that is scheduled to begin in 2012 — the Western Climate Initiative (WCI). This is discussed further in section K.15.

Box K.2 **Potential for fuel switching in the RGGI — New York**

The following stylised example highlights the potential for a coal-gas switch due to the Regional Greenhouse Gas Initiative in the state of New York.

According to the EIA (US) (2011b, 2011c), in the state of New York coal cost US$3.13 per million Btu and natural gas cost US$7.49 per million Btu in January 2011. On average in the United States in 2009, 10 378 Btu of coal was required per kWh of electricity, and 8160 Btu of natural gas was required per kWh (EIA (US) 2011g).

This implies that the fuel cost of coal generation was approximately US$32.48/MWh, and the fuel cost of natural gas generation was approximately US$61.12/MWh. Given that fuel costs generally make up a large proportion of variable costs, and given the relative emissions intensities of coal and gas (generally around 0.4t/MWh for Combined Cycle Gas Turbines, and around 0.9t/MWh for black coal generation), this implies that a RGGI permit price of around US$60/t CO_2-e would be required before there would be a large short-run switch from coal to gas in New York. (Note that a lower carbon price could potentially result in a long-run change in investment decisions, however this is not considered here.)

Sources: EIA (US) (2011b, 2011c, 2011g).

K.5 Renewable Electricity Production Tax Credits

The Renewable Electricity Production Tax Credit (PTC) was initially introduced in 1992 as a per kWh tax credit for electricity generated from eligible renewable sources. It is provided to renewable energy generation in the commercial, industrial and agricultural sectors that on-sell electricity to an unrelated party. The PTC has expired twice since its introduction, once at the end of 2001 (renewed in March 2002) and again at the end of 2003 (renewed in October 2004). During this time, solar was eligible for the PTC for a period of one year. However, in general the PTC is not available for solar.

The current rate of the PTC is US 1.1 cents or US 2.2 cents per kWh and is generally available for the first 10 years of operation of eligible renewable generators.[2] Renewable energy generators eligible for the US 2.2 cent rate are wind, closed-loop biomass, geothermal, and solar. Renewable generators eligible for the US 1.1 cent rate are open-loop biomass, small hydro, landfill, waste, wave and tidal (IRS (US) 2010b).

2 With the exception of open loop biomass, geothermal, small hydro, landfill gas and municipal solid waste placed in service after October 2004, which are eligible for the credit for a period of five years.

Estimating the subsidy equivalent

The Commission's approach to estimating the subsidy equivalent of production tax incentives is analogous to the approach used for renewable energy target schemes and feed-in tariffs.

In the case of the PTC, the subsidy equivalent is equal to the value of the production tax credit per MWh (US$11 or US$22/MWh) multiplied by the amount of generation receiving the production tax credit in 2010 — this is also the value of the foregone tax revenue ('tax expenditure') to the US Government.

The Commission obtained a number of US Government estimates of the value of the PTC over the past several years. However, none of these estimates identified the amount or source of renewable electricity generation that received the PTC. Therefore, the Commission has used data from the Energy Information Administration (US) (2011m, 2011n) to estimate the total renewable electricity generation eligible for the PTC in 2009 (the most recent year for which data were available) and then multiplied this figure by the rate of the PTC in 2010 to estimate the subsidy equivalent in 2010. The Commission used this approach as it provided a consistent method for estimating abatement from the PTC.

Table K.4 shows the Commission's estimate of the amount of renewable electricity eligible for the PTC in 2009 — 75 TWh. Multiplying this figure by rate of the tax credit in 2010 (US$11 or US$22/MWh) provides an upper bound estimate of the value of the PTC (the subsidy equivalent) in 2010 of US$1.6 billion (A$1.7 billion).

Table K.4 **Estimating the value of the PTC**
United States, 2010

	Estimate of eligible generation (TWh)[a]	*Tax credit*	*Estimated value of tax credit*
	TWh	2009 US$/MWh	US$ m
Wind	66.6	22	1 466
Geothermal	1.3	22	28
Closed-loop biomass[b]	1.6	11	18
Hydro	1.7	11	19
Landfill	3.7	11	40
Municipal waste	0.1	11	0.7
Solar	0.0	22	–
Total (2010 US$)	**74.9**	**..**	**1 571**
Total (2010 A$)			**1 708**

a Data on eligible generation estimated by Vivid Economics using data from EIA 'Form 860' and EIA 'Form 923' (EIA (US) 2011i, 2011j). Electricity generators that elected to take the Treasury Grant in 2009 have been excluded from the estimate using the '1603 Grant' database from the US Treasury Department (2011b). **b** Open-loop biomass is granted a tax credit of US$22/MWh. There did not appear to be any eligible open-loop biomass in 2009. .. Not applicable – Nil or rounded to zero.

Sources: Vivid Economics, Productivity Commission estimates.

The Commission considers that using the 2009 generation estimates and the 2010 PTC rates provides a reasonable proxy for the value of the PTC in 2010, as it can be assumed that the majority of operators receiving the PTC in 2009 would also be receiving the PTC in 2010 — with the exception of those that may have shut down or reached the 5 or 10 year eligibility threshold for the PTC.

However, there are two factors that may affect the Commission's estimate for 2010. First, the estimate does not include eligible renewable generators constructed in 2010 that elected to take the PTC rather than the Treasury Grant or the ITC. However, the Commission considers that this is not likely to have had a significant effect on the estimates as:

- in 2009, when the cash grant was introduced, around two-thirds of wind projects elected to take the Treasury Grant (Linn 2011)
- the value of Treasury Grants for new wind in 2010 was large (around US$ 3.5 billion), which makes up the largest component of the Treasury Grants (around 90 per cent).

This led the Commission to assume that a large proportion of new wind projects in 2010 may also have elected to take the Treasury Grant in lieu of the PTC.

Second, not all eligible renewable electricity generation companies would have been eligible for the full PTC in 2009. In particular, the PTC is reduced for projects that receive other federal tax credits, grants, tax-exempt financing or subsidised energy financing (DSIRE 2011).

K.6 Treasury Grants

The US Federal Government enacted the American Recovery and Reinvestment Act of 2009 (US) (ARRA) in February 2009 as an economic stimulus package following the 2008 global financial crisis. The package included a number of measures aimed at stimulating economic activity and investment, one of which was Section 1603 — the Renewable Energy Grant program (the 'Treasury Grant'). The Treasury Grant provides a cash grant of either 30 per cent or 10 per cent of the capital costs of a number of renewable energy sources in the commercial, industrial and agricultural sectors.

The 30 per cent rate applies to fuel cells, solar, wind, biomass, geothermal (other than geothermal heat pumps), landfill, municipal waste, hydro, and marine-related electricity production. The 10 per cent rate applies to geothermal heat pumps, microturbines and combined heat and power (CHP).

The Treasury Grant is only available to tax-paying entities and can be taken in lieu of other Federal tax incentives (the Renewable Energy Investment Tax Credit (ITC) or the Renewable Energy Production Tax Credit (PTC)). Grants are available for renewable energy generators placed in operation in 2009, 2010 and 2011 (or afterwards if construction began before the end of 2011) after which time the grant is expected to cease. Grants are paid after the renewable electricity generator is placed in operation (US Treasury Department 2011a).

Estimating the subsidy equivalent

The Treasury Grant is provided as an upfront cash payment. Therefore, the Commission has estimated the subsidy equivalent of the program by annualising the total value of grants paid over the period 2009 and 2010. This is consistent with the approach used for other capital subsidies.

Data from the US Treasury Department (2011b) indicated that the total value of grants paid to eligible renewable electricity generators over 2009 and 2010 was US$5.7 billion (A$6.2 billion) in real 2010 values (table K.5).

Table K.5 **Treasury Grants, value of grants**[a]

United States, 2009, 2010

	2009	*2010*	*Total*
	US$m	US$m	US$m
Wind	1 380	3 477	4 857
Solar	27	374	401
Combined heat and power	0	5	5
Fuel cells	2	3	4
Small wind	0	49	49
Landfill gas	3	7	10
Biomass	71	44	115
Geothermal	119	141	261
Hydro	4	3	7
Marine	0	0	0
Microturbine	0	0	0
Waste	0	3	3
Total (US$)	1 607	4 105	5 712
Total (2010 US$)	**1 622**	**4 105**	**5 727**
Total (2010 A$)	**1 764**	**4 462**	**6 226**

a Grant data are provided for electricity generation only and exclude solar thermal and geothermal used for heat as these are outside the scope of the Commission's analysis.

Sources: US Treasury Department (2011b), Productivity Commission estimates.

The estimated annualised value (subsidy equivalent) of these grants in 2010 was US$541 million (A$588 million) — based on an interest rate of 7 per cent and an average economic life of renewable electricity assets of 20 years.

Estimating annual generation

The US Treasury has estimated the total annual generation for 2011 from assets supported by the Treasury Grants program for the period 2009 to 2011 (table K.6).

Using these data, and data on the value of grants to renewable energy producers in 2009 and 2010, the Commission estimated the annual generation from renewable energy in 2009 and 2010. The process was, for each type of renewable, to estimate the proportion of total expenditure over the period February 2009 to February 2011 that was paid out in 2009 and 2010. This was done by:

1. dividing the total value of grants paid in 2009 and 2010 by the total value of grants paid for renewable electricity over the period 2009 to February 2011
2. these proportions were then applied to US Treasury data on total annual generation from the Treasury Grants program over the period 2009 to end February 2011 to estimate annual renewable electricity generation by source in 2010.

Using this approach, the Commission estimated annual electricity generation from the Treasury Grants program in 2010 of 22.3 TWh, the large majority of which was wind (19.9 TWh) (table K.6).

Sensitivity analysis

The Commission carried out sensitivity analysis using discount rate values of 3 and 11 per cent. Using these values, the subsidy equivalent of the Treasury Grants program is estimated to be between US$385 million (A$418 million) and US$719 million (A$782 million) in 2010 respectively.

Table K.6 **Estimated renewable generation attributable to the Treasury Grants program**

United States, 2010

	Total value of grants (Jan 2009 to Feb 2011)[a]	*Total value of grants (2009 to 2010)*[a]	*Proportion of grants paid in 2009 and 2010*	*Total annual generation (2011)*	*Estimate of annual generation in 2010*[b]
	US$m	US$m	%	GWh	GWh
Biomass	116	115	99.5	855	851
Geothermal	268	267	99.7	805	783
Solar	757	405	53.4	715	379
Wind	5 246	4 906	93.5	21 302	19 921
Other[c]	54	29	53.6	756	405
Total	**6 441**	**5 722**	**88.8**	**24 433**	**22 339**

[a] The total value of grants paid includes all grants paid to renewable energy generation (including geothermal and solar thermal used for heating purposes). Hence, figures for the total value of grants (2009 to 2010) in table K.6 are slightly different to those provided in table K.5. [b] Annual generation for 2010 was estimated by applying the proportion of grants paid in 2009 and 2010 to the data on generation from generators installed over the period January 2009 to end February 2011. However, the Commission was unable to determine how much generation from geothermal and solar was for heat related purposes. Therefore, the proportion of total payments for geothermal and solar thermal that are related to heat have been subtracted from the Commission's estimates of annual generation in 2010 (these proportions are 2 per cent and 1 per cent respectively). [c] Includes CHP, fuel cells, landfill gas, biomass, hydropower, marine, microturbines and municipal waste.

Sources: US Treasury Department (2011b, 2011c), Productivity Commission estimates.

K.7 Renewable Portfolio Standards

A majority of US states have enacted renewable portfolio standards (RPSs) — targets to increase the use of renewable energy. Generally these are expressed as a longer-term target (for example, 20 per cent renewable energy by 2020), with less stringent targets gradually ramping up over the years. In some cases, the targets are simply aspirational, and do not include any mechanism for achieving the target or penalty for failure. Other schemes include incentives and penalties. The Commission did not attempt to estimate the subsidy equivalent of schemes with no compliance mechanism.

While RPSs differ across the states, there are some features that are common to most. Most schemes place an obligation on electricity utilities to provide a certain proportion of their total sales of electricity from renewable sources. In several states, the RPSs include 'carve outs' that mandate that a proportion of the target must come from particular renewable technologies, such as solar PV. Compliance is generally demonstrated through the surrender of renewable energy certificates (RECs) — one REC is created for each MWh of electricity generated from

approved renewable sources. Some states allow utilities to meet targets with RECs created in other states.

The Commission estimated the subsidy equivalent to RPSs in a subset of states for 2009.[3] A number of states were excluded from the analysis for reasons of data availability and relative significance (the excluded states and the reasons for exclusion are set out below).

The Commission's preferred approach to estimating the subsidy equivalent for each RPS is to use the total number of RECs surrendered in 2009 for additional 'induced' generation, multiplied by the average REC price. This is the approach that was taken for similar schemes in Australia and the United Kingdom. However, this information was not available for most RPS states. The Commission's analysis suggests that many electricity utilities meet their RPS obligations through direct ownership of renewable sources, or through bilateral contracts with renewable energy generators. This means that REC trading appears to be limited and data on REC prices are not readily available. Instead, the Commission has used a number of proxies and assumptions to derive illustrative estimates of the subsidy equivalent and abatement. The following sections describe the approaches used for each state.

For each state, the Commission attempted to estimate the proportion of renewables that have been induced by that state's RPS. This was done by comparing generation in the years prior to the commencement of the scheme with the RPS targets for 2009. In some cases, the Commission concluded that the RPS has probably not induced any additional generation to date.

While the approach taken to estimate the subsidy equivalents varies from state to state, the results for each state are of a similar order of magnitude to the estimates for other jurisdictions. Where the estimates for a state are significantly larger or smaller than for other states, the Commission has attempted to explain the divergence.

The Commission has not carried out sensitivity analysis on the results of the analysis. The reason is that there is only one parameter that stands out as an candidate for such analysis: the emissions intensity of the counterfactual generator. The Commission's estimates of the abatement attributable to each RPS are based on estimates of the marginal emissions factor in each of the ten US electricity markets (section K.1). While these are only estimates, the Commission did not identify any

[3] The Commission assessed the effects of RPSs in the following states in 2009: California, Minnesota, Colorado, Massachusetts, Connecticut, Illinois and Montana. For New York, the year of analysis is the year to 30 April 2010. For New Mexico, the Commission was only able to obtain data for 2007.

alternatives that would be strong candidates for use in sensitivity analysis. As such, it was determined that such analysis would not add significantly to the study.

California

California has the highest renewable energy target of all the US states — 33 per cent of retail sales must be met by renewable energy by 2020 (the target for 2010 was 33 per cent). The California Public Utilities Commission (Fitch 2011) stated that total procurement of RPS-eligible renewables by utilities in California was around 27 TWh in 2009 (15.4 per cent of total electricity sales). Almost all of this was accounted for by three utilities: Pacific Gas and Electric, Southern California Edison and San Diego Gas and Electric.

Policy-induced generation

The California RPS was adopted in September 2002. Prior to the adoption of the scheme, California already had significant renewable energy capacity. Fitch (2011) stated that RPS eligible procurement in 2003 was equal to around 22 TWh. The Commission has assumed that only generation in excess of the 2003 figure should be considered to have been induced by the policy. (That is, around 5 TWh in 2009.)

Estimating the subsidy equivalent

There is little public information on the cost of renewables in California that could be used to estimate the subsidy equivalent. Instead, the Commission has used the following information from the Pacific Gas and Electric (PGE) Company's 2009 annual report (PGE 2009) and its 2010 RPS compliance report (PGE 2011).

- In 2009, PGE's total renewable procurement target was 11.5 TWh — 14.2 per cent of PGE's total retail electricity (PGE 2011).
- PGE stated that it paid out US$706 million in 2009 for 'renewable energy and capacity payments' that accounted for 7 per cent of its electricity sources (PGE 2009, p. 106). The Commission has assumed that this is equal to around 5.7 TWh (= (11.5 TWh / 0.142) x 0.07). (The implication of this calculation is that PGE achieved almost half of its RPS obligations through renewables that the company owned, rather than purchased from other firms.)
- This implies that PGE paid around US$124/MWh for renewables. The Commission has assumed that this is a reasonable estimate of the average cost of renewables for the three major electricity utilities in California.

- In 2009, PGE purchased approximately 43 TWh of electricity (including renewables and non-renewables). The average price it paid was US$0.082/kWh ($82/MWh) (PGE 2009). The Commission was not able to obtain data on the price that PGE paid for non-renewable electricity. Instead, the Commission has used the figure of $82/MWh as a proxy estimate of the cost of conventional electricity. This is likely to imply that the estimate of the subsidy to renewables is a lower-bound.
- Hence, the Commission's lower-bound estimate of the production subsidy equivalent for renewables purchased by PGE in 2009 is around US$42/MWh (=US$124 – US$82). Using the Commission's approach for estimating the production subsidy equivalent, this would be the imputed price of RECs.

The Commission has used these assumptions to estimate the subsidy equivalent from the California RPS of US$206 million (A$224 million) (table K.7).

Table K.7 **California RPS calculations**
United States, 2009

Variable	*Units*	*Value*
Total RPS-induced generation	GWh	4 851
Production subsidy equivalent	US$/MWh	42
Subsidy equivalent	**US$m (2009)**	**206**
	A$m (2010)	**224**

Sources: Fitch (2011); PGE (2009, 2011); Productivity Commission estimates.

Illinois

Under the Illinois RPS, privately-owned utilities that serve over 100 000 customers are obliged to obtain a minimum percentage of their electricity from renewables. In 2009, the RPS was 4 per cent, and in each year, 75 per cent of total renewables must come from wind. There are two utilities that are of sufficient size to have obligations under the scheme (ComEd and Amaren Corporation).

Policy-induced generation

The Illinois RPS was introduced in 2007, and allows utilities to meet their RPS obligations using new or existing renewables. Total renewable generation in 2006 was 1 TWh (EIA (US) 2007). Renewable generation in 2009 was 3.7 TWh. Therefore, around 28 per cent of total 2009 renewable generation in Illinois existed in 2006. This suggests that the policy had a significant impact on investment in

renewables, particularly wind power. To reflect this, the Commission has assumed that 72 per cent of renewable generation in Illinois can be attributed to the RPS.

Estimating the subsidy equivalent

The Commission obtained data on the number of RECs purchased and the prices paid by ComEd and Amaren Corporation to meet their obligations for wind energy and other renewables (Evolution Markets 2009). These data were used to estimate the subsidy equivalent paid out by each company (table K.8). It is not clear why ComEd paid significantly more than Amaren for its wind RECs. In a competitive market, both utilities would be expected to pay the same price. One possible explanation is that some utilities enter into long-term contracts for the purchase of RECs. This could lock them (or the seller) into higher (or lower) REC prices in a given year. Another possible explanation is that the REC market might not be very liquid. Alternatively, the firms could have purchased RECs at different times during the year, meaning that the difference could be explained by REC price fluctuations.

Table K.8 **Illinois RPS calculations**
United States, 2009

Variable	*Units*	*ComEd*	*Amaren Corporation*	*Total*
Total RECs purchased	millions	1.6	0.7	2.3
Wind[a]	millions	1.2	0.5	1.7
Other renewables	millions	0.4	0.2	0.6
RECs purchased for induced generation[b]				
Wind	millions	0.8	0.4	1.2
Other renewables	millions	0.3	0.1	0.4
Price paid per REC				
Wind	US$ (2009)	21.13	16.66	
Other renewables	US$ (2009)	13.69	13.46	
Subsidy equivalent				
Wind	$USm (2009)	18	6	24
Non-wind	$USm (2009)	4	2	6
Total	**$USm (2009)**	**22**	**8**	**30**
	A$m (2010)	**24**	**9**	**33**

a Assuming that 75 per cent of RECs purchased by utilities are for wind power, as per the RPS requirement. **b** Assuming that 72 per cent of renewables covered by the RPS are policy-induced.

Sources: Evolution Markets 2009; Productivity Commission estimates.

New York

New York has a state renewable energy target of 30 per cent by 2015. The state RPS operates through a tender system, whereby the responsible authority (NYSERDA):

> … pays a production incentive to renewable electricity generators selected through competitive solicitations for the electricity they deliver for end use in New York. In exchange for the production incentive, the renewable generator transfers to NYSERDA all rights and/or claims to the RPS Attributes associated with each MWh of renewable electricity generated … (NYSERDA 2010a, p. 5)

NYSERDA does not purchase renewable electricity. Rather, the payment is for the 'RPS attributes', including 'reductions in harmful pollutants and emissions, such as carbon dioxide and oxides of sulphur and nitrogen' (NYSERDA 2010a, p. 5). These are 'similar to Renewable Energy Certificates that are commonly used in other RPS programs' (NYSERDA 2010a, p. 5). The value of reductions in non-greenhouse pollutants could be making some contribution to the price of 'RPS attributes'. However, the Commission was not able to unbundle the greenhouse gas portion of the price from other elements. Hence, the Commission has assumed that the value of an 'RPS attribute' can be used in the same way that REC prices are used to estimate the subsidy equivalent for other schemes.

The RPS consists of two 'tiers'. The 'main tier' (tier 1)consists mainly of medium and large-scale generators, while the 'customer-sited' tier consists of smaller facilities, such as photovoltaic systems. Due to changes in the funding of the program, the Commission was not able to access data that could be used to calculate the subsidy equivalent for the customer-sited tier. However, this tier of the program accounted for only around 2 per cent of total RPS procurement in the year to 30 April 2010. Hence, it is likely that excluding this part of the scheme from the analysis will not have a significant effect on the estimated subsidy equivalent or abatement.

Policy-induced generation

Proceedings to enact the RPS began in February 2003. NYSERDA states that '[o]nly renewable energy systems installed on or after January 1, 2003 are eligible to participate in the RPS' (2010a, p. 7). Based on this, the Commission has assumed that all renewables that create RPS attributes are policy induced.

Estimating the subsidy equivalent

The Commission has estimated the subsidy equivalent using the price of 'RPS attributes' in the same way it would normally use REC prices. To date, NYSERDA has held five 'solicitations' for the main tier of the program (medium and large-scale generators). The weighted average price of RPS attributes through these solicitations was US$18 for each RPS 'attribute' associated with a MWh of renewable electricity. The total annual average renewable electricity generation was around 4.3 TWh. The Commission has used these figures to estimate the subsidy equivalent arising from the RPS (table K.9).

Table K.9 **New York RPS calculations**

Main tier, May 2009 – April 2010

Variable	*Units*	*Value*
Tier 1 annual generation	TWh	4.3
Weighted average incentive payment	US$ (2009)	18
Subsidy equivalent	**US$m (2009)**	**78**
	A$m (2010)	**85**

Sources: NYSERDA (2010a); Productivity Commission estimates.

Montana

The Montana Renewable Energy Standard (RES) required 5 per cent of electricity sales to come from renewables in 2009, 10 per cent in 2010, and 15 per cent in 2011 and thereafter (UCS 2008a). The scheme applies to public utilities regulated by the Montana State Public Service Commission, and to competitive electricity suppliers. In 2004, these suppliers amounted to approximately 58 per cent of state electricity sales (UCS 2008a). The RES incorporates REC trading, and a penalty of US$10/MWh for non-compliance.

Policy-induced generation

The Montana RES was enacted in April 2005. Only facilities that commenced operation after 1 January 2005 are counted toward the scheme. For the purpose of estimating the subsidy equivalent, the Commission assumed that all eligible generation is policy induced (that is, firms with RES obligations adhere to the rules of the scheme and only submit RECs for electricity generated from facilities that commenced during 2005 or later).

Estimating the subsidy equivalent

The EIA (US) (2010e) stated that total electricity sales in Montana in 2009 were 14 TWh. The Commission assumed that the RES applied to 58 per cent of total sales, and that the utilities covered by the scheme met their obligation to supply 5 per cent of their total sales from post-2005 renewables.

The Commission was not able to locate data on REC prices in Montana. Instead, the Commission used the penalty price ($10/MWh) to estimate an upper bound of the subsidy equivalent (table K.10). Given the relatively low penalty price, it is possible that the RPS is not inducing significant quantities of renewable generation (for example, utilities might find it cheaper to simply pay the penalty). This should be taken into account when interpreting the results.

Table K.10 **Montana RES calculations**
United States, 2009

Variable	*Units*	*Value*
Total electricity sales	TWh	14.3
Electricity sales by utilities with RES obligations[a]	TWh	8.3
Total RPS obligation of covered utilities	TWh	0.42
Penalty price	US$/MWh	10
Subsidy equivalent[b]	**US$m (2009)**	**4.2**
	A$m (2010)	**4.6**

a Assuming that 58 per cent of total sales are by utilities with RES obligations. **b** This estimate represents an upper bound. If the REC price is lower than the penalty price (US$10/MWh), or the RES obligation was not met, the subsidy equivalent would be smaller.

Sources: EIA (US) (2010e); UCS (2008a); Productivity Commission estimates.

Minnesota

The Minnesota RES imposed an obligation on the utility company Xcel Energy to provide 15 per cent of its retail electricity sales from renewables in 2010. For other utility companies, the figure was 7 per cent. The Commission was not able to determine whether there was a specific obligation for 2009.

Policy-induced generation

Minnesota's total renewable generation in 2006 (the year before the RES was enacted) was around 3.6 TWh (EIA (US) 2007). In 2009, renewable generation was around 7.5 TWh (EIA (US) 2010d). The Commission assumed that only the additional generation (around 3.9 TWh) can be attributed to the RES.

Estimating the subsidy equivalent

The Commission was not able to access data on REC prices in Minnesota. However, because Minnesota is in the same region as Illinois, and operates on the same electricity grid, the Commission has used the Illinois REC prices to estimate the average REC price in Minnesota (table K.11). This is based on the assumption that the marginal costs of renewables in the two states are similar.

Table K.11 **Minnesota RES calculations**
United States, 2009

Variable	*Units*	*Value*
Total renewable generation (2006)	TWh	3.6
Total renewable generation (2009)	TWh	7.5
Estimated RES-induced generation	TWh	3.9
Estimated REC price[a]	US$/MWh	17.30
Subsidy equivalent[b]	**US$m (2009)**	**68**
	A$m (2010)	**74**

[a] Based on the average REC price for wind energy in Illinois in 2009 (US$18.90) and non-wind RECs (US$13.58). The estimate was weighted 70 per cent wind and 30 per cent 'other'.

Sources: EIA (US) (2007, 2010d); Productivity Commission estimates.

Colorado

Under the Colorado Renewable Energy Standard, at least 5 per cent of 2009 electricity sales by privately-owned utilities were required to be sourced from renewables. For rural cooperatives and municipal utilities the figure was 1 per cent. The scheme includes a 'carve out' that at least 4 per cent of total renewable generation must come from solar electric technologies.

Policy-induced generation

Total electricity sales in Colorado in 2009 were around 51 TWh, which implies that up to 2.6 TWh of renewables would be required to meet the RES target (this is an upper-bound estimate that would only apply if all electricity was supplied by privately-owned utilities). The Colorado RES commenced in 2004. In 2004, total renewable generation in Colorado was less than 1.5 TWh, most of which came from hydroelectricity (EIA (US) 2007). By 2009, the figure had risen to 5.3 TWh, with most of the growth accounted for by wind power (EIA (US) 2010e). That implies that the total new (post-2004) renewable generation in Colorado is more than is required by the state RES. The excess wind could have been installed as a result of

other programs, (such as the Federal PTC or Treasury Grants, or other state programs. Alternatively, the capacity could have been installed in order to export renewable energy (and RECs) to other states with RPSs. Another possibility is that the capacity could have been installed to meet future renewable energy targets.

The Commission did not attempt to identify the reasons for the relatively high level of capacity in Colorado (relative to the RES target), because this is not required for the calculation of the subsidy equivalent and abatement attributable to the RES. The relevant figure for these purposes is how much renewable energy was subsidised under the RES. To estimate this figure, the Commission assumed that to meet the RES obligation, utilities purchased all of the existing renewable energy (assumed to equal 1.5 TWh) and 1.1 TWh of new wind power. Note that this is likely to overestimate the total RES obligations in Colorado in 2009, because utilities that are not privately-owned have less stringent obligations. As such, the Commission's estimates of abatement and subsidy equivalent represent an upper bound.

Estimating the subsidy equivalent

The Commission's analysis suggests that Colorado utilities meet their REC obligations through bilateral contracts with renewable generators, or through privately-owned sources. Hence, the Commission was not able to access data on REC prices.

Instead, the Commission imputed the value of RECs by using data on Xcel Energy's Windsource program. This scheme provides a mechanism for customers of Xcel Energy to purchase additional renewable energy (beyond that required under the RES). Under this program, for each MWh of renewable electricity purchased through Windsource that would not have been purchased otherwise, one REC is retired. Hence the price of renewables purchased for the Windsource program can be used as a proxy for the REC price. Specifically, the 'Windsource premium' represents the price consumers are prepared to pay for RECs, and hence may be an upper-bound estimate of the REC price, if consumers are motivated by environmental concerns to pay a premium to retire RECs.

Xcel Energy stated that it anticipated that its sales through this program would be 220 GWh in 2009 (Xcel Energy 2009), and that the 'Windsource premium' for the last nine months of 2009 would be US$3.4 million. The Commission assumed that the total Windsource premium for 2009 would be US$4.5 million (= US3.4 million x 1.33). This implies that the premium per MWh (and the imputed upper bound of the REC price) would be US$20.61. This assumption was used to estimate the subsidy equivalent for the Colorado RES (table K.12).

Note that this estimate does not account for the solar 'carve out' under the scheme (data were not available). However, the carve out target is small (4 per cent of total renewables), and the exclusion of this part of the scheme would not be expected to have a material effect on the estimates.

Table K.12 **Colorado RES calculations**
United States, 2009

Variable	*Units*	*Value*
Estimated policy-induced renewable generation (upper bound)	TWh	1.1
Estimated REC price (upper bound)[a]	US$/MWh	20.61
Subsidy equivalent[b]	**US$m (2009)**	**23**
	A$m (2010)	**25**

[a] Based on the Xcel Energy Windsource program.

Sources: EIA (US) (2007, 2010d); Productivity Commission estimates.

New Mexico

The New Mexico RPS obliged privately-owned utilities to derive 5 per cent of their retail sales from renewables since 2006, and requires 10 per cent from 2011. Three utilities have obligations under the RPS: El Paso Electric; Public Service Company of New Mexico; and Southwestern Public Service. The Commission was not able to locate data on the retail sales or RPS obligations of these companies for 2009, and instead has analysed the RPS for 2007.

Policy-induced generation

The New Mexico RPS came into force in 2004. Generators are permitted to use renewable generation assets that were in their generation portfolios as of July 2004 to meet their RPS obligations, except for hydro power, which must have been brought into service after 2007. The Commission was not able to access data on the renewable assets that were in utilities' portfolios in 2004, and has made the simplifying assumption that all generation used to meet the New Mexico RPS was policy-induced. This assumption might overstate the subsidy equivalent and abatement attributable to the New Mexico RPS.

Estimating the subsidy equivalent

The Commission was not able to obtain data on New Mexico REC prices. However, as is the case for Colorado, the utility companies in New Mexico operate voluntary schemes to enable electricity consumers to purchase additional renewable energy (New Mexico Public Regulation Commission 2008). The Commission used these prices as a proxy for the REC prices in its estimates of the subsidy equivalent (table K.13).

Table K.13 **New Mexico RPS calculations**
United States, 2007

Variable	*Units*	*Value*
RPS obligation (2007)		
El Paso Electric	GWh	96
Public Service Company of New Mexico	GWh	503
Southwestern Public Service	GWh	246
Estimated REC price[a]		
El Paso Electric	US$/MWh (2007)	22.80
Public Service Company of New Mexico	US$/MWh (2007)	16.90
Southwestern Public Service	US$/MWh (2007)	30
Subsidy equivalent[b]	**US$m (2007)**	**18**
	A$m (2010)	**20**

a Based on the voluntary programs run by each utility for the purchase of renewable energy. **b** Estimated as the RPS obligation multiplied by the estimated REC price for each utility, then added for a total figure.

Sources: New Mexico Public Regulation Commission (2008); Productivity Commission estimates.

Massachusetts

The Massachusetts Renewable Energy Portfolio Standard (REPS) requirement for 2009 was for 4 per cent of electricity to be generated from renewables that were installed during 1998 or later ('Class I' renewables). Massachusetts also imposes an obligation to use energy from generators that existed before 1998 ('Class II' renewables). Because 'Class II' renewables are not induced by the policy, the Commission did not include these in the analysis. Finally, there is an obligation to use a certain proportion of 'alternative' energy technologies, including flywheel energy storage and CHP. The alternative energy obligation was relatively minor (164 GWh), and for this reason was not considered in the analysis. Hence, the Commission's estimate of the subsidy equivalent and abatement for Massachusetts applies only to the 'Class I' portion of the scheme.

Policy-induced generation

The Massachusetts REPS came into force in 1997. Only generation that was put into service in 1998 or later is eligible to meet the target for Class I renewables. For this reason, the Commission has assumed that all generation that was used to meet this obligation was policy-induced.

Estimating the subsidy equivalent

In 2009, the Class I obligation was equal to around 2 TWh. In February 2010, Evolution Markets (2010, p. 10) stated that '2009 Massachusetts Class 1 RECs are currently assessed between $23.50 and $25.50'. The Commission assumed that the REC price in 2009 was US$24.50. This implies that the subsidy equivalent was around US$47 million (A$52 million) in 2009 (table K.14)

Table K.14 **Massachusetts REPS calculations (Class I Only)**
United States, 2009

Variable	*Units*	*Value*
2009 Class I REC obligation	million	1.9
Estimated 2009 Class I REC price	US$ (2009)	24.50
Subsidy equivalent (cost of RECs retired)	**US$m (2009)**	**47**
	A$m (2010)	**52**

Sources: Commonwealth of Massachusetts Department of Energy Resources 2010; Productivity Commission estimates.

Connecticut

The Connecticut RPS includes targets for the use of renewables and CHP. The 2009 targets were:

- 6 per cent from 'Class I' — includes solar, wind, some biomass, biogas and some hydropower
- 3 per cent from 'Class II' — waste to energy, biomass that began operation before 1998, and small hydropower
- 3 per cent from 'Class III' — CHP.

The Commission was only able to access data on the price of Class I RECs. For this reason, the estimates of the subsidy equivalent and abatement apply only to that portion of the RPS.

Policy-induced generation

Under the Connecticut RPS, new and existing generation can be used to meet the Class I target (except for hydropower, which is only eligible if installed after 2003). The Commission was not able to access data on how much new generation used to meet the target. Hence, it has made the simplifying assumption that all generation used to meet the target is policy-induced. This may tend to overstate the subsidy equivalent and the abatement attributable to the Connecticut RPS.

Estimating the subsidy equivalent

Based on data from a REC market operator (Evolution Markets 2009, p. 1), the Commission assumed that the 2009 price of Connecticut Class I RECs was US$20.

Total electricity sales in Connecticut in 2009 were around 29.7 TWh (EIA (US) 2010e). The Commission assumed that the Class I obligation of 6 per cent of total sales was met. This implies that around 1.8 TWh of Class I renewables were supplied in 2009. Using this information it is possible to estimate the subsidy equivalent of the Connecticut RPS (table K.15).

Table K.15 **Connecticut RPS calculations (Class I only)**
United States, 2009

Variable	*Units*	*Value*
2009 Class I REC obligation	million	1.8
Estimated 2009 REC price	US$ (2009)	20
Subsidy equivalent (cost of RECs retired)	**US$m(2009)**	**36**
	A$m (2010)	**39**

Sources: EIA (US) (2010e); Evolution Markets (2009); Productivity Commission estimates.

States that were not analysed

The Commission analysed only a sub-set of states. There were a variety of reasons for excluding states:

- Fourteen states do not have an RPS (Alabama, Alaska, Arkansas, Florida, Georgia, Idaho, Indiana, Kentucky, Louisiana, Mississippi, Nebraska, South Carolina, Tennessee and Wyoming).
- Seven states have RPSs that set an 'aspirational' target, but with no compulsion for electricity retailers or generators to achieve the target (North Dakota, South Dakota, Oklahoma, Utah, Vermont, Virginia and West Virginia).

- Seven states have an RPS that commenced in 2011, and as such data, data were not available (Iowa, Kansas, Michigan, Missouri, North Carolina, Oregon and Washington).

States where the RPS does not appear to be inducing significant generation

In some states the 2009 RPS target was relatively low, compared to the renewable generation that existed before the introduction of the policy. In these cases, the Commission concluded that the RPS probably did not induce significant additional renewable generation in 2009. In general, this assessment was made by comparing historical generation data (EIA (US) 2007) with 2009 generation data and the state RPS targets. States omitted on this basis include the following:

- Pennsylvania — the Pennsylvania Alternative Energy Portfolio Standard (AEPS) was enacted in November 2004. Generation from both new and existing sources can be counted toward AEPS obligations. Data from EIA (US) (2007) show that 2004 renewable generation was around 2.2 TWh from hydropower and 2.3 TWh from 'other renewables'. The 2009 AEPS obligation was for around 1.2 TWh — less than the generation that occurred prior to the AEPS (Pennsylvania Public Utility Commission 2010).
- New Hampshire — the 2009 RPS target was for 6 per cent of total electricity sales to be derived from renewables. However, 5.5 percentage points of the target could be met with existing renewables. Hence, the Commission considers that the RPS probably led to little additional renewable generation in 2009, and as such has not attempted to estimate a subsidy equivalent.
- Nevada — the RPS was introduced in 2004. It obliges utilities to meet a percentage of total electricity sales from renewable energy or efficiency measures. In 2009, the figure was 12 per cent, with a maximum of 3 per cent to come from efficiency measure. Hence, the RPS set a minimum of 9 per cent renewable generation. In 2004, renewables accounted for around 8.4 per cent of Nevada's total generation (EIA (US) 2007). Given that the 2009 target is only slightly above this figure, the Commission has opted to exclude Nevada.

In addition, the Commission excluded Texas from its analysis because the 2009 REC price was approximately zero (Linn 2011). Maryland was excluded for similar reasons. Data from the Public Service Commission of Maryland implied that the 2009 REC price was only around A$1.20 per REC. This suggests that the Maryland RPS did not lead to significant additional renewable generation in 2009.

States with a small target for new renewables in the year of analysis

Some states had a relatively small target for new renewables in the year of analysis (2009). These states were excluded from the analysis because it is unlikely that the subsidy equivalents were material relative to those in other states with larger targets. States excluded on this basis were:

- Arizona (2 per cent new renewables in 2009)
- Maine (2 per cent new renewables in 2009)
- Ohio (0.25 per cent renewables in 2009)
- Wisconsin (no reduction in the state's renewable energy generation over the period 2006–2009, and a 2 per cent increase in 2010 renewables against a baseline).

States with less than 1 TWh of renewable generation in 2009

The Commission has opted to exclude from its analysis states with a reported generation from renewables of less than 1 TWh in 2009.

Between them, the two largest states that the Commission has assessed (California and New York) generated over 85 TWh of electricity from renewable sources in 2009. States with low levels of renewable generation could still have effective RPSs if their laws permit imported RECs to count toward the target. However, as a proxy measure, the Commission has assumed that in states with less than 1 TWh of renewable generation in 2009, the subsidy equivalents would be small, relative to the larger states in the analysis. States excluded on this basis (and their 2009 renewables generation) are:

- Delaware (126 GWh)
- Rhode Island (150 GWh)
- New Jersey (790 GWh)
- Hawaii (817 GWh).

K.8 Abatement and the implicit abatement subsidies for federal policies and state RPSs

Due to overlap between the federal Treasury Grants and Production Tax Credits, and state Renewable Portfolio Standards, the Commission has estimated the abatement and implicit abatement subsidy from these three schemes as a group. In estimating abatement, the Commission assumed that:

- all renewable generators eligible to receive either the federal Production Tax Credits or the federal Treasury Grants took these subsidies. As such, abatement from the majority of renewable sources is covered under these two schemes
- eligible renewable generation from the Renewable Portfolio Standards is fully covered by the federal schemes
- because eligible renewable generators are only able to access one of the two federal level programs, there is no overlap between these two scheme.

Therefore, abatement for these three policies is estimated to be equal to the abatement from the Treasury Grants and the Production Tax Credits. This is not to suggest that there is zero abatement from the Renewable Portfolio Standards, or that the abatement estimate for the two federal level polices is solely attributable to those programs. In many cases, it is likely to be the combination of state and federal-level subsidies that induces additional renewable generation. In many cases, the state level Renewable Portfolio Standard may be the 'binding' policy that drives new renewable generation in a given state. However, as the renewable generation from the state Renewable Portfolio Standards is already covered by the federal level programs, the Commission excluded this generation to avoid double counting abatement.

Estimating abatement

As discussed in section K.1, the US electricity system is made up of ten separate electricity markets, each of which uses different electricity generation sources. Hence, each have considerably different emissions intensities. Therefore, abatement from the Treasury Grants and Production Tax Credits depends on the location of generation from each new renewable electricity source.

Total generation eligible for the Production Tax Credits was estimated to be 74.9 TWh (table K.4) based on the proportion of eligible generation in each electricity grid. This implies an abatement estimate of 51 Mt CO_2 (table K.16).

For the Treasury Grants, the Commission was unable to obtain state-level data on renewable generators receiving grants. However, it was able to obtain state-level data on total renewable electricity capacity supported by Treasury Grants. The Commission used these data to weight the marginal emissions intensities of the 10 US electricity markets. This provides a weighted average marginal emissions intensity for the US as a whole of 0.67 t CO_2/MWh (table K.17).

Table K.16 **Estimated abatement from the PTC**

United States, 2010

Electricity market	*Total eligible generation*	*Marginal emissions factor*	*Abatement*
	TWh	t CO_2/MWh	Mt CO_2
California (CAISO)	4.2	0.41	1.7
Midwest (MISO)	22.1	0.91	20.0
New England (ISO-NE)	0.4	0.60	0.3
New York (NYISO)	2.6	0.60	1.6
Northwest	11.0	0.47	5.2
PJM	3.0	0.79	2.4
Southeast	1.9	0.77	1.4
Southwest	4.8	0.47	2.2
Southwest Power Pool	6.0	0.79	4.7
Texas (ERCOT)	18.9	0.60	11.4
Total	74.9		51

Sources: Vivid Economics (2011); Productivity Commission estimates.

Abatement from the Treasury Grants program was estimated using the Commission's estimate of total annual generation and the weighted average emissions intensity for the United States as whole. This provides an estimate of abatement from the Treasury Grants program of 15.1 Mt CO_2.[4]

Based on the above analysis, abatement from the Treasury Grants, Production Tax Credits and state-based Renewable Portfolio Standards combined was estimated to be 66 Mt CO_2.

Estimating the implicit abatement subsidy

The implicit abatement subsidy for renewables supported by the Treasury Grants, Production Tax Credits and state-based Renewable Portfolio Standards was estimated by adding the subsidy equivalent estimates for each measure (sections K.5–K.7) and dividing this by the combined abatement estimate above. This provides an implicit abatement subsidy in the range US$37-US$42/t CO_2 (A$41-A$46) (table K.18).

4 Note that the Commission's estimates of abatement assume that all new generation supported by the Treasury Grants have zero emissions (renewable generators). This is not the case for CHP. However, the Commission was unable to obtain data on the annual generation or location of CHP plants supported by the program in order to estimate abatement from CHP. This does not have a material effect on the estimates as CHP is a very small component of the program (0.09 per cent of total payments in 2009 and 2010).

Table K.17 **Estimated weighted average marginal emissions factor[a]**

Electricity market	*Estimated installed capacity (as of February 2011)*	*% of total installed capacity*	*Marginal emissions factor*
	MW	%	t CO_2/MWh
California (CAISO)	331	3	0.41
Midwest (MISO)	3 056	31	0.91
New England (ISO-NE)	218	2	0.60
New York (NYISO)	481	5	0.60
Northwest	1 907	20	0.47
PJM	580	6	0.79
Southeast	89	1	0.77
Southwest	458	5	0.47
SPP (Southwest Power Pool)	161	2	0.79
Texas (ERCOT)	2 447	25	0.60
Weighted average			0.67

a Installed capacity by electricity market was estimated by Vivid Economics by allocating states (and total capacity by state) to one of the 10 electricity markets based on the location of states and by using information from the Federal Energy Regulatory Commission. Due to insufficient data, Alaska, Hawaii and Puerto Rico were not included in the analysis. The exclusion of these states is not expected to have a material effect on the Commission's estimate of the average emissions intensity as combined these states represent around 0.08 per cent of total installed capacity.

Sources: US Treasury Department (2011c), Productivity Commission estimates.

Table K.18 **Implicit abatement subsidies**

United States, 2010

	Subsidy equivalent		*Abatement*	*Implicit abatement subsidy*	
	US$	A$m	Mt CO2	US$/t CO_2	A$/t CO_2
Renewable Electricity Production Tax Credits	1 571	1 708	..	..	..
Treasury Grants			..	..	..
- 3 per cent discount rate	385	418	..	..	..
- 7 per cent discount rate	541	588	..	..	..
- 11 per cent discount rate	719	782	..	..	..
State Renewable Portfolio Standards	512	557	..	..	..
Total	**2 468–2 803**	**2 684–3 047**	**66**	**37–42**	**41–46**

Source: Productivity Commission estimates. .. Not applicable

K.9 The California Solar Initiative

The California Solar Initiative (CSI) provides subsidies for the installation of solar panels. These can take two forms

- For small solar systems (under 30kW) — an up-front payment based on the capacity of the system (the 'expected performance-based buydown' (EPBB) payment). This is paid upon completion of the system.
- For larger solar systems — an annual payment for five years based on the actually generation of the system (the performance-based incentive (PBI payment).

The rate of subsidy is dependent on the amount of solar installed — as more solar is installed, the tariff gradually steps down. The rates started at US$2.80/watt for the EPBB and US$0.50/kWh for the PBI in 2007, and will reach US$0.20/watt (EPBB) and US$0.03/kWh (PBI) by the end of the scheme. As of 2010, much of the state is in step 8, which implies an EPBB payment of US$0.35/watt, and a PBI payment of US$0.05/kWh (RFF 2011).

The scheme has a budget of US$2.2 billion between 2007 and 2016, and a goal to install 1940 MW of new solar capacity by 2016.

Estimating the subsidy equivalent

The Commission's approach for estimating the subsidy equivalent was different for the EPBB payments and the PBI payments.

EPBB payments

As the EPBB is provided as an upfront cash subsidy, the subsidy equivalent from this part of the CSI was estimated as a capital subsidy.

According to the CEC and CPUC (2011), by the end of 2010, US$361 million of EPBB payments had been classed as completed since the scheme commenced. Converting to 2010 values, this implies that the total outlay paid under the EPBB scheme was US$365 million.

Using a discount rate of 7 per cent, and an expected economic lifetime of solar PV of 20 years, the annualised subsidy equivalent of the EPBB scheme was estimated at US$34 million (A$37 million) (table K.19).

Table K.19 **Estimating the EPBB payments**
California, 2010

Data	*Value*
Total payments made	US$365m
Discount rate	7 per cent
Lifetime of solar panels	20 years
Annualised cost (subsidy equivalent)	**US$34m**
	A$37m

Source: Productivity Commission estimates.

PBI payments

The PBI payments are paid out annually over five years on the basis of actual generation. Therefore, these payments are similar to production subsidy schemes, such as feed-in tariffs and renewable energy certificate schemes, and the subsidy equivalent was estimated on this basis.

While no data on the actual total PBI payments over a year were available, an estimate of the annual payments can be implied from data from the CEC and CPUC (2011).

As of the end of December 2010, owners of installed solar PV panels were expected to receive US$452 million under the PBI over the five years (CEC and CPUC 2011). This includes those that are still receiving payments, and those whole payments had recently ceased, but would still have been paid in the previous year. Dividing this figure by 5 provides an estimate of the expected annual production subsidy to solar panels under the PBI payments (US$90 million).

Total

The annual estimated subsidy equivalent provided by the CSI is the sum of the PBI and EPBB subsidy equivalents — US$125 million (A$136 million).

Sensitivity analysis

The Commission used two alternative discount rate scenarios for the EPBB estimates: 3 per cent and 11 per cent.

- A 3 per cent discount rate resulted in a subsidy equivalent estimate of US$115 million (A$125 million).

- An 11 per cent discount rate resulted in a subsidy equivalent estimate of US$136 million (A$148 million).

Estimating total generation

As of the end of 2010, 461 MW of solar capacity had been subsidised under the CSI. Annual generation is estimated using capacity factors for the Californian Self Generation Incentive Program (section K.11) reported by Iltron (2010) — 17 per cent for solar. Therefore the estimated annual generation was 690 GWh.

Summary

Table K.20 displays the results of the analysis for the CSI. The subsidy equivalent estimates range from US$115 million to US$136 million (A$125 million to A$148 million).

Table K.20 **Summary, California Solar Initiative**
California, 2010

Scenario	*Subsidy equivalent*		*Generation*
	A$m	US$m	GWh
'Central'	136	125	690
Low discount rate	125	115	690
High discount rate	148	136	690

Source: Productivity Commission estimates.

K.10 New Solar Homes Partnership

The California New Solar Homes Partnership (NSHP) aims to encourage the use of solar PV systems on new homes. The NSHP offers more generous subsidies than the CSI for new homes in specified areas. The scheme objective is for an additional 400 MW of installed solar capacity by 2016.

The subsidy rate currently ranges from US$2.50/watt to US$2.60/watt for 'market rate housing', and US$3.30/watt to US$3.50/watt for 'affordable housing'. The rebates are paid as a lump sum, once the system is installed.

Estimating the subsidy equivalent

As the NSHP payments are provided up-front payment, the subsidy equivalent was estimated as a capital subsidy. As of the end of 2010, US$29.7 million worth of subsidies had been paid out (Vivid Economics). Converting this to real 2010 currency, the estimated total outlay was US$29.9 million.

Using an interest rate of 7 per cent, and an economic lifetime of 20 years, the annualised subsidy equivalent was estimated to be US$2.8 million (A$3.1 million).

Sensitivity analysis

The Commission used two alternative discount rates in its sensitivity analysis: 3 per cent and 11 per cent.

- Using a 3 per cent discount rate results in a subsidy equivalent estimate of US$2 million (A$2.2 million).
- Using an 11 per cent discount rate results in a subsidy equivalent estimate of US$3.7 million (A$4.1 million).

Estimating generation

As of the end of 2010, 10.5 MW of solar PV had been installed under this scheme (Vivid Economics). Using a capacity factor of 17 per cent (Iltron 2010), this capacity was estimated to produce 15.7 GWh per year.

Summary

Table K.21 outlines the results of the estimate of the California NSHP. The subsidy equivalent estimates range from US$2 million to US$3.8 million (A$2.2 million to A$4.1 million)

Table K.21 **Summary, NSHP**
California, 2010

Scenario	*Subsidy equivalent*		*Generation*
	A$m	US$m	GWh
'Central'	3.1	2.8	15.7
Low discount rate	2.2	2	15.7
High discount rate	4.1	3.7	15.7

Source: Productivity Commission estimates.

K.11 Self Generation Incentive Program

The Self Generation Incentive Program (SGIP) provides up-front capital subsidies for on-site generation facilities. Currently, fuel cells (renewable and non-renewable), wind and energy storage are eligible for the SGIP. Previously, other technologies such as solar and internal combustion units have been eligible. (Note that as past subsidies to these previously eligible technologies are still contributing to abatement, and have a subsidy equivalent in 2010 under the Commission's approach, they are still included in the estimates.)

The current subsidy rates are shown in table K.22, and range from US$1.50/W for wind to US$4.50/W for renewable fuel cells. For systems bigger than 1 MW, the subsidy is 100 per cent of this subsidy rate for the first MW, 50 per cent for capacity between 1 and 2 MW, and 25 per cent for capacity between 2 and 3 MW. No incentive is paid for capacity above 3 MW, and systems above 5 MW are not eligible for the SGIP.

The SGIP was initially conceived as a peak-load electricity reduction measure. However it also has the effect of increasing the use of renewable sources of electricity (CPUC nd).

Table K.22 **Subsidy rates for the SGIP (for the first MW of capacity)**
California, 2010

Technology	*Subsidy rate*
	US$/W
Wind turbine	1.50
Renewable fuel cells	4.50
Non-renewable fuel cells	2.50
Advanced energy storage	2.00

Source: SCE et al. (2010).

Calculating the subsidy equivalent

Effectively, there are two components to the SGIP — payments to renewable technologies, and payments to non-renewable technologies (primarily natural gas). Subsidies to non-renewable technologies are unlikely to lead to any abatement — given the largely gas-based Californian electricity system — and therefore they have not been included in the estimates. Fuel cells, internal combustion engines and micro-turbines fuelled by biomass have been included in the analysis.

According to data from CSEC (2011), as of the end of 2010, US$532 million had been paid out to renewable technologies under the SGIP. This was converted to 2010 values, resulting in an estimated total outlay of US$573 million.

Using an interest rate of 7 per cent, and an average economic lifetime of projects of 20 years, this value was converted into an annualised cost, estimated at US$54 million (A$59 million) (table K.23).

Table K.23 **Estimating the subsidy equivalent, SGIP**
California, 2010

Data	*Value*
Value of payments	US$573 million
Interest rate	7 per cent
Economic lifetime	20 years
Annualised value of payments (subsidy equivalent)	US$54 million
Subsidy equivalent (AU$)	**A$59 million**

Sources: CSEC (2011); Productivity Commission estimates.

Sensitivity analysis

The Commission used two alternative discount rates: 3 per cent and 11 per cent.

- Using a 3 per cent discount rate results in a subsidy equivalent estimate of US$38.5 million (A$41.9 million)
- Using an 11 per cent discount rate results in a subsidy equivalent estimate of US$72 million (A$78.3 million).

Estimating abatement

As of the end of 2010, the SGIP had subsidised:

- 4 MW of wind
- 144 MW of solar
- 22 MW of biomass and waste, of which 3.9 MW was micro-turbines, 10.8 MW was internal combustion units, and 7.9 MW was fuel cells (CSEC 2011).

Iltron (2010) sets out capacity factors for generation subsidised by the SGIP for 2009. These are used as a proxy for 2010 capacity factors, as there is unlikely to be a significant change in capacity factors between 2009 and 2010. According to Iltron (2010):

- the capacity factor for solar PV was 17 per cent. This results in estimated annual generation of 216 GWh
- the capacity factor for wind was 17 per cent. This results in estimated annual generation of 5.8 GWh
- the capacity factor for renewable fuel cells was 51 per cent. This results in estimated annual generation of 35 GWh
- the capacity factor for micro-turbines was 22 per cent. This results in estimated annual generation of 7.5 GWh
- the capacity factor for internal combustion was 28 per cent. This results in estimated annual generation of 26 GWh.

Therefore, the total annual generation supported by the scheme was estimated at 290 GWh (of which 216 GWh was solar).

Sensitivity analysis

Counterfactual emissions intensity

As noted in section K.1, the Commission used an alternate counterfactual emissions intensity of 0.6t/MWh for the Californian schemes. This results in an implicit abatement subsidy estimate of US$311/t CO_2 (A$338).

Summary

The results of the estimation for the SGIP are shown in table K.24. The subsidy equivalent estimates range from US$38.5 million to US$72 million (A$41.9 million to A$78.3 million).

Table K.24 **Summary, Self Generation Incentive Program**
California, 2010

Scenario	*Subsidy equivalent*		*Solar generation*	*Non solar generation*
	A$m	US$m	GWh	GWh
'Central'	59	54	216	74
Low discount rate	42	39	216	74
High discount rate	78	72	216	74

Source: Productivity Commission estimates.

K.12 Emerging Renewable Program

The Californian Emerging Renewable Program (ERP) commenced in 1998, and has provided subsidies for solar PV, wind and renewable fuel cell generation. The scheme is designed to favour small-scale distributed generation. The current subsidy rates vary between US$1.50/watt and US$3.00/watt, depending on the generators fuel type and size (CEC 2010c). Since 2007, this scheme no longer offers incentives for solar, which was the largest component of scheme.

Estimating the subsidy equivalent

Since the commencement of the scheme in 1998, the ERP has provided US$406 million in subsidies (CEC 2010a, 2010b) (US$453 million in 2010 dollars).

Using an interest rate of 7 per cent, and an expected economic lifetime of the subsidised assets of 20 years, the subsidy equivalent was estimated at US$42.7 million (A$46.5 million).

Sensitivity analysis

The Commission used two alternate discount rates for sensitivity analysis: 3 per cent and 11 per cent.

- Using a 3 per cent discount rate results in a subsidy equivalent estimate of US$30.4 million (A$33.1 million).
- Using an 11 per cent discount rate results in a subsidy equivalent estimate of US$56.8 million (A$61.8 million).

Estimating generation

Since the commencement of the program, the ERP has subsidised:

- 123 MW of solar PV
- 2.9 MW of wind
- 0.02 MW of fuel cells (CEC 2010a, 2010b).

Iltron (2010) stated that the capacity factor of these sources is 17 per cent for solar and wind, and 51 per cent for fuel cell generation. Using these capacity factors, the annual generation of the subsidised sources was estimated to be:

- 184 GWh from solar PV

- 4.3 GWh from wind
- 0.1 GWh from fuel cells
- 189 GWh of total generation.

Summary

Based on the Commission's sensitivity analysis, the estimates of the subsidy equivalent for the ERP for 2010 vary from US$30 million to US$57 million (A$33 million to A$62 million) (table K.25).

Table K.25 **Summary, Emerging Renewables Program**
California, 2010

Scenario	*Subsidy equivalent*		*Solar generation*	*Non-solar generation*
	A$m	US$m	GWh	GWh
'Central'	47	43	184	4
Low discount rate	33	30	184	4
High discount rate	62	57	184	4

Source: Productivity Commission estimates.

K.13 Summary, Californian capital subsidies

This section combines the estimates for the four Californian capital subsidies (the CSI, NSHP, SGIP and ERP) to estimate a combined subsidy equivalent, abatement and implicit abatement subsidy covering these schemes.

The subsidy equivalent

The subsidy equivalent for the Californian capital subsidies was estimated by simply adding up the four policy subsidy equivalents. This give a figure of between US$186 million and US$269 million (A$202 million and A$292 million) respectively, with a 'central' estimate of US$225 million (A$244 million) (table K.26).

Table K.26 **Subsidy equivalent, California capital subsidies**
California, 2010

	'Central'	*High*	*Low*	*'Central'*	*High*	*Low*
	A$m	A$m	A$m	US$m	US$m	US$m
The California Solar Initiative	136	148	125	125	136	115
New Solar Homes Project	3	4	2	3	4	2
Self Generation Incentive Program	59	78	42	54	72	39
Emerging Renewables Program	46	62	33	43	57	30
Total	**244**	**292**	**202**	**225**	**269**	**186**

Source: Productivity Commission estimates.

Abatement

The abatement for the California capital subsidies was estimated by multiplying the total generation 'induced' by the schemes by a counterfactual emissions intensity value.

In the case of the Californian capital subsidies, only the solar generation covered is relevant for the abatement estimates. This is because the other generation sources covered by these schemes (such as biomass, wind and fuel cells) are likely to be covered under one of the federal schemes analysed. While these sources receive an additional subsidy under the Californian schemes, they are not leading to any additional abatement.

The scheme covered 1.1 TWh of annual solar PV generation. The relevant counterfactual is the counterfactual emissions intensity of the Californian grid, which was assumed to be 0.406t CO_2/MWh. Therefore, the abatement attributed to the Californian schemes is estimated to be 449 kt CO_2.

Alternatively, according to Linn (2011), using this emissions intensity may understate the actual counterfactual emissions intensity. This is because solar may be displacing less efficient, and thus more emissions-intensive gas-fired generation. As such, an alternative emissions intensity of 0.6t CO_2/MWh was used for sensitivity analysis. This results in an abatement estimate of 663 kt.

The implicit abatement subsidy

Using the estimates outlined above, the implicit abatement subsidy for the Californian capital subsidies was estimated to be between US$280 and US$599/t CO_2 (A$305 and A$651), with a 'central' estimate of US$500/t CO_2 (A$544).

K.14 Summary

This section sets out the Commission's estimate of the total subsidy equivalent and abatement attributable to the seven US electricity generation policies. These policies represent only a sub-set of the emissions reduction policies in place at federal and state levels in the US. The Commission has attempted to focus on the policies that are likely to be having the largest effects on emissions. However, time and data constraints mean that there may be other policies that are contributing material abatement or subsidies to low-emissions generation.

The total subsidy equivalent

The subsidy equivalent estimates represent the effective subsidy granted to low-emissions generation from each scheme. These can be added up, to provide an estimate of the total subsidy equivalent for the policies analysed in the US electricity generation sector.

This was estimated at between US$2.7 billion and US$3.1 billion (A$2.9 billion and A$3.3 billion) (table K.27). This estimate is around 0.02 per cent of US GDP.

Table K.27 **Total subsidy equivalent**
United States, 2010

	Australian Dollars			*US Dollars*		
Policy	*'Central'*	*High*	*Low*	*'Central'*	*High*	*Low*
	A$m	A$m	A$m	US$m	US$m	US$m
Federal policies and state RPSs						
Renewable Electricity Production Tax Credits	1 708	1 708	1 708	1 571	1 571	1 571
Treasury Grants	588	782	418	541	719	385
Renewable Portfolio Standards	557	557	557	507	507	507
Californian schemes						
California Solar Initiative	136	148	125	125	136	115
New Solar Homes	3	4	2	3	4	2
Self-Generation Incentive Program	59	78	42	54	72	39
Emerging Renewables Program	46	62	33	43	57	30
Total	**3 097**	**3 339**	**2 886**	**2 848**	**3 071**	**2 654**

Source: Productivity Commission estimates.

Total abatement

Policy overlaps were described in section K.3. Taking into account these overlaps, the abatement estimates from these policies were added together to provide an estimate for the total abatement in the United States. This was estimated to be between 66 Mt CO_2 and 67 Mt CO_2 (table K.28). This is around 2.8–2.9 per cent of US counterfactual emissions from electricity in 2009.

Table K.28 **Total abatement**
United States, 2010

	Central	*High*	*Low*
	Mt CO_2	Mt CO_2	Mt CO_2
Federal policies and state RPSs	66	66	66
Californian solar subsidies	0.5	0.7	0.5
Total	**66**	**67**	**66**

Source: Productivity Commission estimates.

The average implicit abatement subsidy

Using the estimates outlined above, the Commission estimated an average implicit abatement subsidy for the US electricity sector of between US$39.80 and US$46.20/t CO_2 (A$43.27 and A$50.23) (table K.29).

The estimates of the average implicit abatement subsidy are relatively low compared to other countries. The reason for this is that the estimates of the total subsidy equivalent and total abatement are dominated by two policies: the Renewable Electricity Production Tax Credits and the Treasury Grants. These two federal programs provide significant subsidies to renewables. However, it is likely that some of the policies that the Commission has not analysed provide additional subsidies. For example, many states provide tax incentives for renewable energy generators. Omitting these policies from the analysis would tend to lead to lower estimates of the total subsidy equivalent and implicit abatement subsidy. It is likely that a more detailed analysis of the US electricity generation sector that covered all state-level policies would result in a higher estimate of both. As such, the Commission's estimates should be interpreted as a lower bound estimate of the total subsidy equivalent and implicit abatement subsidy.

Table K.29 **Average implicit abatement subsidy**
United States, 2010

		Total abatement					
		Australian Dollars			*US Dollars*		
		High	*'Central'*	*Low*	*High*	*'Central'*	*Low*
		A$/t CO_2	A$/t CO_2	A$/t CO_2	US$/t CO_2	US$/t CO_2	US$/t CO_2
Total subsidy equivalent	High	50.07	50.23	50.23	46.05	46.20	46.20
	'Central'	46.44	46.59	46.59	42.71	42.85	42.85
	Low	43.27	43.41	43.41	39.80	39.93	39.93

Source: Productivity Commission estimates.

K.15 Other US policies

The policies included in the Commission's estimates represent a subset of US policies targeted at the electricity generation sector that are likely to have the largest impact on the electricity generation sector, both in terms of abatement and subsidies provided. However, a number of policies were excluded from the analysis, either due to immateriality or lack of data. In addition, the United States is introducing a number of other policies that may have an impact on the US estimates in the future.

Excluded policies

Time and data constraints meant that the Commission had to exclude some policies from its analysis. A number of policies were excluded on the grounds that they were not likely to be material, relative to the other policies analysed. In particular, state-based schemes, aside from those in California and the renewable portfolio standards, were not included in the analysis (this includes state-based feed-in tariff schemes — box K.3). While in aggregate these schemes may have an impact, the Commission also considers it likely that many of these schemes would overlap with the federal schemes estimated and the state-based renewable portfolio standards,. Thus, their inclusion would be unlikely to result in a large increase in estimated abatement in the United States. The effect of including these policies in the estimates would most likely be to increase the total subsidy equivalent and the implicit abatement subsidy.

Box K.3 **Feed-in tariffs**

Feed-in tariffs (FITs) for renewable energy exist in some US states, and at a Federal level (through the Renewable Energy Production Incentive — REPI). The Commission has not estimated a subsidy equivalent or abatement for these schemes because:

- the REPI is unlikely to be material — funding was US$5 million in 2008 and 2009, and zero in 2010
- state FITs are mainly commercial arrangements between large generators and small-scale generators that the utilities use to meet their RPS obligations
- the Californian FIT was excluded because the FIT paid to renewable generators is based on the cost of generation from a combined-cycle gas turbine plant. As such, the FIT does not offer a subsidy in excess of the cost of conventional electricity.
- one scheme — the Washington Renewable Energy Production Incentives — appears to offer FITs to renewable energy generators. However, the Commission was unable to access data on the amount of generation supported by the scheme, or total payments.

Sources: CPUC (2011), US Department of Energy (2009).

Federal-level schemes that were not considered material in comparison to the other schemes include the following:

- High Energy Cost Grant Program — grants for energy supply in rural areas, including for improvements in energy generation, transmission and distribution. Grants range from US$75 000 to US$5 million.
- Rural Energy for America Program — grants to agricultural producers and small rural businesses for renewable energy and energy efficiency improvements.
- Renewable Energy Deployment Grants — 50 per cent grant for the construction of small renewable energy projects.
- Modified Accelerated Cost-Recovery System — depreciation deductions for businesses that invest in renewable energy technologies.
- Nuclear Power Production Tax Credit — tax credit of US$0.018/kWh for 6000 MW of nuclear energy. At the time of writing, the credit does not appear to have been used as yet.
- Public Utility Regulatory Policies Act — electricity from renewables must be purchased at avoided cost rates.
- Green Power Purchasing — new federal Government buildings must use a certain proportion of renewable energy ‘to the extent it is economically feasible’.
- Loans Guarantee Program (box K.4) — offers loan guarantees to clean energy technologies. Under this scheme, firms generally pay the credit subsidy (the

expected default risk to the government). However, under a scheme introduced as part of the American Recovery and Reinvestment Act, the government pays the credit subsidy.

In addition to the above, there are some policies that were excluded from the analysis because the necessary data were not available. These include:

- Clean Coal Investment Tax Credits
- CO_2 Capture and Sequestration Tax Credits
- Business Energy Investment Tax Credits
- Residential Renewable Energy Tax Credits.

Clean Coal Investment Tax Credits

In the 2005 Energy Policy Act (US), the US Government announced US$1.3 billion to subsidise 'clean coal' generation. Under this program, integrated-gasification combined-cycle coal plants can receive a 20 per cent investment tax credit, and other advanced coal technologies can receive a 15 per cent credit. An additional US$1.3 billion was announced in 2008, with the credit increased to 30 per cent where 65 per cent of CO_2 was sequestered.

According to the Office of Management and Budget (OMB 2009; 2010; 2011), an estimated US$450 million had been paid out under this scheme by the end of 2010. Using the standard approach to estimate the cost of capital subsidies (with a 7 per cent discount rate and economic lifetime of 35 years), this would result in a subsidy equivalent estimate of US$42 million per year (A$46 million).

However, little information was available on the plants that this subsidy funded, their generation, and thus the abatement induced by this scheme. Indeed, it is not known whether the subsidised plants were in operation as of the end of 2010. As such, this scheme has not been included in the estimates.

CO_2 Capture and Sequestration Tax Credits

The US carbon dioxide capture and sequestration tax credit provides a subsidy for each tonne of carbon dioxide (that would otherwise be released into the atmosphere) captured from an industrial facility and sequestered. In 2010, the credit was:

- US$20.24/t CO_2 sequestered, that is not used as a tertiary injectant in an oil or gas recovery project
- US$10.12/t CO_2 for carbon dioxide used as a tertiary injectant.

According to OMB (2011), in 2010 the estimated budgetary cost of the CO_2 sequestration credit was US$20 million — implying that between 1 MT–2 MT of CO_2 was sequestered. However, data were not available on how much of this occurred within the electricity generation sector, and as such this scheme has not been included in the estimates.

Box K.4 Subsidy equivalent, Loan Guarantee Scheme

Under the loan guarantee scheme introduced as part of the American Recovery and Reinvestment Act (US), government pays a credit subsidy (the expected default risk to the government) for guaranteed loans. This entails a subsidy to the guaranteed projects. Receiving a loan guarantee does not exclude a project from receiving other federal government incentives, such as Production Tax Credits.

While a subsidy equivalent for 2010 for this scheme can be estimated, abatement — and therefore an implicit abatement subsidy, for 2010 was not estimated. The reason is that while firms received the loan guarantees in 2010, none of the subsidised generators had finished construction in 2010, and therefore the actual abatement in 2010 would be zero. As such, this scheme was not included in the estimates.

Estimating the subsidy equivalent

According to the Loan Programs Office (LPO 2011), five renewable electricity projects were supported in 2010. US$3 billion of loans were guaranteed from these five projects.

An estimate of the 2010 credit subsidy rate of 14.53 per cent is provided in the 2011 US Government budget (OMB 2011, p. 440). Therefore, the estimated value of the credit subsidy is US$442 million (A$480 million).

As this is an up-front subsidy, this value was annualised using the same approach as for capital subsidies. Using a discount rate of 7 per cent, and an expected economic lifetime of the assets of 20 years, the subsidy equivalent is estimated as A$45 million per year (US$42 million).

As there was no abatement in 2010, the Loan Programs Office estimated that, once complete, the projects will result in annual generation of 3.3 TWh, and annual CO_2 abatement of 2 Mt CO_2. This implies an implicit abatement subsidy, once all projects are fully operational, of between A$16 and A$30/t CO_2 (provided they are not receiving any other subsidies).

Source: LPO (2011).

Business Energy Investment Tax Credits (ITC)

The ITC offers a tax credit for 30 per cent of expenditures for commercial, industrial and agricultural capital investments in solar, small fuel cells and small wind turbines (up to 100 kW capacity) and a tax credit of 10 per cent of expenditures for capital investments in geothermal systems, microturbines and CHP (IRS (US) 2010a).

Due to data constraints, the Commission was unable to estimate the implicit abatement subsidy of the ITC. However, this was not considered to have a material effect on the Commission's aggregate estimates for the United States. In particular, the value of the ITC in 2010 is considered to be small relative to the size of the Treasury Grants and PTC in 2010. The OMB provided an estimate of the value of the ITC tax expenditure in the 2010 fiscal year of $US270 million (OMB (US) 2010).

Residential Renewable Energy Tax Credits (RTC)

The RTC was introduced in 2005 and provides a 30 per cent tax credit for eligible renewable energy technologies installed in residential dwellings. The tax credit is provided for solar hot water, solar photovoltaic, small wind, fuel cells, and geothermal heat pumps. The RTC is similar in operation to the ITC for commercial and industrial renewable energy operators.

The Commission was unable to obtain data or estimates on the value of the foregone revenue for the RTC or the amount or source of residential renewable electricity supported by the scheme. As a result, the Commission was unable to estimate the subsidy equivalent or abatement of the RTC.

Committed policies

The Commission identified two policies that have been committed to by state and federal government in the United States that have the potential to deliver significant emissions reductions in the future.

EPA Greenhouse Gas Regulations

The US Environmental Protection Agency has scheduled that from 2011, fossil fuel power plants will be subject to emissions standards. It appears that plants will be required to meet emissions limits using the 'best available technology'. However, there is much uncertainty over the form these standards could take.

Western Climate Initiative (WCI)

The Western Climate Initiative (WCI) is an agreement between seven US states and four Canadian provinces to implement a cap-and-trade emissions trading scheme. At this stage, it appears that only California is fully committed to implementing an emissions trading scheme by 2012 (chapter 2).

The WCI aims to reduce emissions to 15 per cent below 2005 levels by 2020. Electricity and large industrial facilities are scheduled to be covered by the ETS in 2012, with the scheme expanding to include transport and other fuels in 2015 (WCI 2010).

The WCI has recommended that the 2012 cap be the same as projected 2012 emissions (WCI 2010). Therefore, it is likely that the permit price and abatement will be close to zero. The cap will tighten over time, and it would be expected that the permit price will rise as the scheme progresses.

The California Air Resources Board (CARB 2010) modelled the Californian emissions trading scheme for 2020. Their estimates of the 2020 permit price ranged from US$25/t CO_2-e to US$162/t CO_2-e — depending on the extent to which complementary policies remained in place. Modelling by the WCI (2010) suggested a permit price of between US$13/t CO_2-e and US$50/t CO_2-e in 2020 (2007 US$) for the WCI as a whole.

L Demand-side analysis for electricity

Previous sections of this report have quantified the extent to which policies lead to supply-side abatement in the electricity sector (abatement due to generators shifting to less emissions-intensive technologies). Emissions-reduction policies can also lead to demand-side abatement by electricity consumers (abatement due to lower electricity consumption) if the policy raises electricity prices.[1]

Given data and other constraints (discussed below), the Commission was not able to precisely quantify the extent to which policies increase electricity prices and thereby lead to demand-side abatement. Instead, this appendix presents illustrative estimates of demand-side abatement based on a number of simplifying assumptions. The consumption cost — defined as the consumer valuation of forgone electricity consumption, less the valuation of other goods that can be purchased with the diverted expenditure — is also illustrated by using simplifying assumptions.

The broad approach used to quantify demand-side abatement is outlined in box L.1. A critical input to the calculations was the own-price elasticity of electricity demand (box L.2). In summary, two alternative elasticities were used — -0.2 and -0.7 — to estimate the range within which demand responses seem most likely to occur, given the empirical evidence on elasticities.

The resulting estimates should be considered illustrative, or at best only indicative, rather than being a definitive assessment of demand-side abatement and final consumer-price impacts. This is because it was necessary to make various simplifying assumptions to complete the task within the time and data constraints faced by the study. These include the following.

- It was assumed that the cost borne by electricity generators due to emissions-reduction policies was passed through the value chain and ultimately on to consumers, unless it was clear that the policy was explicitly funded by taxpayers. This provides an upper-bound estimate of the actual increase in electricity prices, since no account was taken of factors — such as retail-price

[1] Demand-side abatement can also result from policies that encourage consumers to increase their energy efficiency at a given electricity price. As noted in chapter 3, energy efficiency policies are not included in this study's quantitative analysis due to uncertainty about their impacts.

regulation and competitive pressures — that can limit producers' scope to pass cost increases on to their customers.

- Differences in policy coverage and electricity prices between different groups of customers — such as residential, commercial and industrial — were factored into the calculations where possible. However, the resulting estimates are unlikely to be as accurate as those generated by industry models that more accurately capture differences between customer groups, including their responsiveness to price changes.
- No account was taken of the compensation that governments sometimes provide to consumers to cushion the price impacts of emissions-reduction policies. Thus, the estimates could overstate the reduction in electricity demand, associated demand-side abatement, and consumption costs.
- For a given country, it was common for one or more variables used in the calculations to be unavailable for the same year as the estimated total subsidy equivalent. In such cases, a mixture of data for adjacent years had to be used. Data constraints also led to inconsistent time periods across countries. Thus, the estimates should only be viewed as being illustrative of recent impacts, rather than a precise quantification of those in a specific year.

The supply-side estimates presented earlier in this report excluded subsidies that do not induce abatement. This was necessary in order to approximate the resource cost of abating emissions. In contrast, the demand-side estimates presented here include all subsidy equivalents associated with a given policy, regardless of whether any abatement is induced. This is done on the grounds that, while no abatement may be achieved, there is a cost and, if it is not explicitly funded by taxpayers, it will be passed on to consumers as higher electricity prices.[2]

[2] The cost of levying taxes to fund the administration of emissions-reduction policies, and to finance taxpayer-funded abatement subsidies, could be passed on to electricity consumers through means other than electricity prices. The Commission has not estimated this in its demand-side analysis.

Box L.1 **Quantifying demand-side abatement for electricity**

The Commission sought to quantify the extent to which emissions-reduction policies increase the price of electricity, and thereby reduce electricity consumption and induce demand-side abatement. The net cost to consumers was also estimated.

In a small number of cases, the price uplift resulting from an emissions-reduction policy had been estimated in a previous study. Such estimates were used where appropriate.

In other cases, it was necessary to estimate the price uplift. To simplify this task, it was assumed that electricity generators pass the full cost of abatement policies on to consumers, unless the policy is explicitly funded by taxpayers. On this basis, the policy-induced change in the electricity price (Δp) was estimated by the formula:

$$\Delta p = (\Sigma R + \Sigma SE)/q_1$$

where ΣR is the total revenue from explicit carbon prices; ΣSE is the subsidy equivalent for other policies, excluding any amounts explicitly funded by taxpayers; and q_1 is (observed) electricity output with the abatement policies in place.

This provided an upper-bound estimate of the actual increase in the electricity price, since no account was taken of factors — such as retail-price regulation and competitive pressures — that can limit producers' scope to pass cost increases on to customers.

The reduction in electricity consumption (Δq) will be:

$$\Delta q = q_0 \left[\varepsilon \left(\frac{\Delta p}{p_0} \right) \right]$$

where q_0 is electricity consumption *without* the abatement policies; p_0 is the electricity price *without* the policies; and ε is the own-price elasticity of demand for electricity (a measure of consumers' responsiveness to price changes, defined in box L.2).

However, q_0 is not observed, and so it is necessary to re-express the above formula in terms of observed consumption (q_1) using the fact that $q_0 = q_1 - \Delta q$ and $p_o = p_1 - \Delta p$:

$$\Delta q = \frac{q_1 \varepsilon \Delta p}{p_1 - \Delta p(1-\varepsilon)}$$

where p_1 is the (observed) electricity price *with* the emissions-reduction policies.

Demand-side abatement of emissions (Δe) was estimated by the formula:

$$\Delta e = a.\Delta q$$

where a is the emissions intensity associated with the output change Δq.

The consumption cost — defined as the consumer valuation of forgone electricity consumption, less the valuation of other goods that can be purchased with the diverted expenditure — was approximated by:

$$\tfrac{1}{2}\Delta p \Delta q$$

using the assumption that the demand curve is linear and supply is perfectly elastic.

Box L.2 **Own-price elasticity of demand for electricity**

The own-price elasticity of electricity demand measures the proportional change in electricity consumption in response to a unit change in the price. It is usually negative, since a price increase will typically reduce consumption. Thus, an elasticity of -0.5 indicates that a 1 per cent rise in the electricity price reduces demand by 0.5 per cent.

The elasticity also tends to be lower in the short term than in the long term, because it takes time for consumers to substitute towards less energy-intensive appliances.

A recent cross-country review of elasticity estimates for electricity demand found that they typically range from -0.2 to -0.4 in the short term, and -0.5 to -0.7 in the long term (Fan and Hyndman 2011). The review also concluded that there was no obvious evidence of significant differences in elasticities between the commercial, residential and industrial sectors. A sample of the reviewed estimates is provided below.

	NIEIR	*Taylor et al.*	*King*	*Reiss*	*Bohi and Zimmerman*	*Beenstock et al.*
Year	2007	2005	2003	2005	1984	1999
Location	Australia	UK	California	California	US	Israel
Residential	-0.25	..	-0.3	-0.39	-0.2 (ST) -0.7 (LT)	-0.21 to -0.58
Commercial	-0.35	..	..	..	..	..
Industrial	-0.38	-0.05 to -0.26	..	..	..	-0.002 to -0.44

ST short term. **LT** long term. **..** Not applicable.

The OECD published a similar review of price elasticity estimates for residential energy demand, which includes space heating, water heating and household electricity consumption. It concluded that there 'is some consensus on the short-run price elasticity [for residential energy demand] being about -0.3' and the 'long-run price elasticity could be -0.7' (Kristrom 2008, p. 108).

Within Australia, the energy-market operator (AEMO 2010a) has used elasticities that range from -0.16 to -0.38 when analysing the electricity market.

Given that there is a range of elasticity estimates within Australia and across countries, the Commission concluded that it would be inappropriate to use a single value in its calculations. Instead, two alternative elasticities were used: -0.2 and -0.7. This provided a range within which the true demand response seems most likely to occur, given the empirical evidence on elasticities.

L.1 Australia

The impact of emissions-reduction policies on retail electricity prices has been a prominent issue in recent debate about Australia's actions to address climate change, and may continue to be so under current regulatory arrangements (Sims 2010). For example, the NSW regulator (IPART 2011a) recently issued a draft decision that would allow retailers to raise regulated tariffs by around 18 per cent on 1 July 2011. Most of this increase (10 per cent) was to cover a rise in network costs (transmission and distribution of electricity). However, much of the remaining increase (6 per cent) was to cover the cost of recent changes to the Renewable Energy Target (RET).[3] This would be in addition to the cost previously allowed for the pre-existing RET, which MMA (2010) estimated would have raised retail electricity prices by around 4 per cent at a national level over 2010–2015.[4] Feed-in tariffs (FITs) and other emissions-reduction policies — such as the NSW Greenhouse Gas Reduction Scheme (GGAS) — have also been argued to have contributed to the growth of electricity prices in recent years (Garnaut 2011).

Analysed policies

The Commission analysed four Australian policies for their demand-side impacts — the (expanded) RET that existed up until the end of 2010, state and territory solar FITs, the Queensland Gas Scheme (QGS), and GGAS. A more detailed description of each of these policies is provided in the analysis of Australian supply-side abatement in appendix D.

The combined carbon-price revenues and subsidy equivalents for the four policies was estimated to be in the range of A$668–845 million per annum. Of this, around A$463–640 million was attributed to the (expanded) RET.

The estimates for the RET take account of the different prices received by small and large-scale generators for renewable energy certificates (RECs) in 2010, and the surplus of RECs in that year.

- For large-scale generators, the lowest and highest subsidy equivalents from the supply-side analysis were used — A$283 million using a lower-bound REC price of A$37.03 and A$459 million using an upper-bound REC price of

[3] About a month after IPART released its draft decision, the Australian Government (Combet and Dreyfus 2011) announced adjustments to the 'solar credits' used for the small-scale component of the RET, which it claimed would reduce the cost to electricity users by around half in 2012.

[4] MMA (2010) estimated that, if the RET that applied in 2010 had remained unchanged, it would have increased retail electricity prices by 4.0 per cent over 2010–2015 if the Carbon Pollution Reduction Scheme (CPRS) had started in 2013, and 4.2 per cent if the CPRS started in 2014.

A$60 respectively. These estimates assume that all 7.6 million RECs created by large-scale generators in 2010 were surrendered to meet the RET target in that year.

- The RET required 12.5 million RECs to be surrendered in 2010 (ORER 2011b). If 7.6 million of these RECS were created by large-scale generators, the remaining 4.9 million RECs had to be created by small-scale generators. Multiplying 4.9 million by the average spot-market price for RECs in 2010 (A$37.03) resulted in an amount of A$181 million for small-scale generators.[5]
- The A$181 million estimate used here for small-scale generators differs from the range of subsidy equivalents estimated in this study's supply-side analysis (A$52–98 million, depending on assumptions) for two reasons. First, the supply-side estimate was based on the number of RECs created in 2010 (28.6 million, excluding RECs for solar water heaters), which was much greater than the 12.5 million RECs that retailers and other large electricity purchasers had to surrender in that year (surplus RECs can be carried over to be surrendered in a later year). Second, the supply-side analysis converted the subsidy for small-scale renewable generators into an annualised figure to reflect the fact that the subsidy was effectively an upfront payment for abatement over several years. Here, it is assumed that the cost that retailers and other large electricity purchasers incur in obtaining a REC is passed on to consumers in the year that it is incurred.

For FITs and QGS, the subsidy equivalents estimated in this study's analysis of supply-side abatement were used (A$96 million and A$38 million respectively).

For GGAS, the Commission estimated that only about 4 per cent of NSW Greenhouse Abatement Certificates (0.6 million out of 15.5 million certificates in 2009) were for abatement that would not otherwise have occurred. Thus, the amount used here to quantify demand-side abatement — A$71 million — is greater than the subsidy equivalent reported in the supply-side analysis (A$3 million).

Australian retail prices

Another key input to the estimation of demand-side abatement was the retail price currently paid by consumers (which is distinct from the wholesale prices used in this report to analyse supply-side abatement). Like other countries, retail electricity prices in Australia vary between customer types (such as households and industry), jurisdictions, retailers within a given state or territory, and according to the level of

[5] As noted in the supply-side analysis (appendix D), the Commission considers the spot-market price to be the most appropriate value to assign to RECs created by small-scale generators.

consumption. This issue could be addressed by calculating a weighted average price across all consumers, with weights being the share of total electricity demand subject to a given price. Such an approach was used for some of the other analysed countries, but it was not possible for Australia because the necessary data were not available.

Instead, the Commission based its Australian demand-side calculations on regulated and standing-offer tariffs offered to residential and small-business customers in each jurisdiction. This information is published regularly by the Office of the Tasmanian Economic Regulator (OTTER 2010) in monitoring reports that compare energy prices across the states and territories. To ascertain the range within which Australian demand-side abatement lies, the Commission used the minimum and maximum electricity prices reported by OTTER (2010) for representative residential and small-business consumers in August 2010. The prices were A$163/MWh and A$282/MWh.[6]

Estimation results and the RET

The Commission's demand-side estimates suggest that the analysed policies raised electricity prices in the range of 1.0–2.3 per cent (table L.1). The resulting emissions reductions were estimated to be in the range of 0.1–2.3 per cent, and the consumption cost in the range of A$0.7–6.9 million. It is possible that these national estimates conceal significant differences between states and territories.

The price increase estimated by the Commission at a national level for all analysed policies is less than the increase of around 4 per cent that MMA (2010) forecast for just the RET over 2010–2015. It appears that most of the difference can be explained by the REC and retail prices that MMA used in its calculations.

- MMA based its estimates on a REC price of around A$55–70 over 2010–2015, whereas the Commission used REC prices in the range of A$37–60.
- MMA estimated its percentage price change relative to an expected retail price of around A$115/MWh for 2010–2015, which was lower than the prices observed by OTTER (2010) and used by the Commission in its calculations (A$163/MWh and A$282/MWh).

6 In August 2010, residential prices, based on average consumption in the relevant state or territory, ranged from $163/MWh (ACT) to $262/MWh (NSW). Small-business prices, for consumption of 150 MWh/year, ranged from $184/MWh (Victoria) to $282/MWh (NSW) (OTTER 2010).

Table L.1 **Estimated demand-side impacts of Australian emissions-reduction policies**

	Units	*Low estimate*	*High estimate*
Inputs to calculations			
Carbon-price revenues and subsidy equivalents	A$m	668	845
Renewable Energy Target	A$m	463	640
Feed-in tariffs	A$m	96	96
Queensland Gas Scheme	A$m	38	38
Greenhouse Gas Reduction Scheme	A$m	71	71
Production[a]	TWh	230	230
Retail price[b]	A$/MWh	282	163
Emissions[c]	Mt CO_2	196	196
Emissions intensity of displaced output[d]	t CO_2/MWh	0.54	1.20
Demand elasticity		-0.2	-0.7
Estimation results			
Change in retail electricity price	%	1.0	2.3
Change in electricity consumption	%	-0.2	-1.6
Change in emissions	%	-0.1	-2.3
Consumption cost:[e]			
total amount	A$m	0.7	6.9
per tonne of demand-side abatement[f]	A$/t CO_2	2.7	1.5

[a] Production in 2008-09 (ABARES 2011). [b] Highest and lowest prices in August 2009, based on a cross-state/territory comparison by OTTER (2010) of amounts paid by residential customers (at average consumption in the relevant state/territory) and small-business customers (using 150 MWh/year) on regulated and standing-offer contracts. The highest price is used to generate the 'low estimate' results (and vice versa) because it minimises (maximises) the proportionate price change from a given amount of carbon-price revenues and subsidy equivalents. [c] 2010 data from DCCEE (2011a). [d] Emissions intensities are the lowest (natural gas) and highest (brown coal) estimates reported in the analysis of supply-side abatement. [e] Consumers' valuation of forgone electricity consumption, less the valuation of other goods that can be purchased with the diverted expenditure. [f] This amount is typically greater for the 'low estimate' because the consumption cost is spread across a smaller reduction in emissions.

Sources: ABARES (2011); DCCEE (2011a); Frontier Economics (unpublished data); OTTER (2010); Productivity Commission estimates.

Using the same REC and retail prices as MMA, the Commission's approach would result in an estimated retail price increase of up to 3.4 per cent in 2010 for the RET alone, which is closer to MMA's results.

Recent changes to the RET are likely to mean that the price increases estimated by MMA are more representative of the RET's future impacts.[7] The RET scheme was changed significantly in January 2011 by splitting it into small and large-scale components. This was done in response to concerns that 'the inclusion of

[7] MMA (2010) estimated that, with the recent changes, the RET would raise retail electricity prices in the range of 4.2–4.4 per cent over 2010–2015.

small-scale technologies and their impact on the renewable energy certificate (REC) market [was] delaying investment in large-scale renewable energy projects' (Australian Government 2010, p. 6; ECALC 2010, p. 2). As noted previously, the number of RECs created in 2010 was far greater than what had to be surrendered in that year. This placed downward pressure on REC prices, to the extent that it raised concerns that the RET did not provide a sufficient incentive to invest in large-scale renewable generation (ECALC 2010). As noted above, IPART (2011a) has proposed a 6 per cent increase in NSW regulated tariffs to cover the cost of the changes made to the RET.[8]

L.2 China

Three of the Chinese policies covered in this study's analysis of supply-side abatement are taxpayer funded, and so are not expected to lead to demand-side abatement.[9] The remaining policies analysed here are the Jiangsu photovoltaic (PV) FITs; wind FITs and value-added tax (VAT) exemption; and biomass FITs. A more detailed description of each of these policies is provided in the analysis of Chinese supply-side abatement in appendix E.

The combined subsidy equivalents for the three policies was estimated to be in the range of CNY 16.5–17.0 billion. This amount was derived as follows.

- In the supply-side analysis, all output subsidised by the Jiangsu PV FITs was assumed to be induced by the policy. Thus, the estimated subsidy equivalent of CNY 516 million from the supply-side analysis can be used here.
- In the supply-side analysis, it was estimated that between 70 and 90 per cent of wind generation was induced by the wind FITs and VAT exemption. Including subsidies paid for generation not induced these policies leads to a subsidy equivalent of CNY 11 954 million.[10]

8 This is more than the average national increase in retail electricity prices that MMA (2010) estimated over 2010–2015 for the most recent version of the RET (4.2–4.4 per cent). Previous estimates by MMA (2009) suggest that the RET causes a higher percentage increase in retail electricity prices in New South Wales than in other states.

9 Large Substitute for Small program, subsidy for solar photovoltaic in buildings, and Golden Sun demonstration scheme.

10 In the supply-side analysis, a range of CNY 8368–10 759 million was estimated for the subsidy equivalent of the wind FITs and VAT exemption. The former figure assumed that 70 per cent of generation was additional and the latter 90 per cent. Adjusting each subsidy equivalent estimate up to include the subsidies paid to non-induced generation leads to the same amount of CNY 11 954 million.

- For the biomass FITs, the Commission estimated that 54 per cent of subsidised production was induced by the policy. Thus, the range used here — CNY 4061–4570 million — is greater than the subsidy equivalent reported in the supply-side analysis (CNY 2193–2468 million).

China currently has a levy of CNY 4/MWh on electricity consumers to help fund the cost of FITs. It could be argued that this should be the price uplift used here to analyse demand-side abatement. However, it would make little difference to the calculations in practice. The Commission's estimate of the price uplift from passing on the cost of the FITs subsidy equivalent was also around CNY 4/MWh.

Other inputs to the calculations were obtained from a range of sources. It was particularly difficult to obtain recent data on two key inputs to the demand-side calculations — total emissions and a retail electricity price. The approach used for these variables is outlined below.

Chinese emissions

An estimate of 2009 emissions was derived by scaling up reported 2005 emissions — 2115 Mt CO_2 according to Malla (2009) — by the percentage increase in electricity production from 2005 to 2009. According to EIA (2011k), Chinese electricity production increased by about 45 per cent from 2005 to 2009 (from 2370 TWh to 3446 TWh). On this basis, 2009 emissions were estimated to be 3075 Mt CO_2. The Commission acknowledges that this estimate overlooks any changes from 2005 to 2009 in the fuel mix used to generate electricity, and efficiency gains that have reduced the emissions intensity associated with specific fuels.[11] However, this did not have a major bearing on the estimated demand-side abatement because the subsidy equivalents associated with analysed policies are relatively insignificant (detailed below).

Chinese retail prices

Chinese retail electricity prices are largely determined at a central level by the National Development and Reform Commission (NDRC) (IEA 2010n). However, prices can vary between regions, including as a result of decisions made by local governments (IEA 2010n; Lan 2010). Moreover, it appears that retail electricity

[11] The Commission did, however, benchmark its approach against a 'bottoms-up' analysis of individual plants by CARMA (2007), which estimated that 2007 emissions were 2830 Mt CO_2 (3120 US (short) tons). Using the Commission's approach, scaling up 2005 emissions (2115 Mt CO_2 according to Malla 2009) by 2005–2007 output growth (28 per cent according to EIA 2011k) results in a similar estimate of around 2710 Mt CO_2 for 2007.

prices have often been set below the cost of production in recent years, particularly for coal-fired generators, leading to significant losses for many producers (China Securities Journal 2011; EIU 2011; Lan 2010). The NDRC recently proposed changing to a new tiered pricing system in which retail prices would rise with consumption. However, this was intended to encourage domestic consumers to save energy and reduce greenhouse gas emissions, rather than to eliminate the losses experienced by generators (China State Power 2010; IEA 2010n; Lan 2010; Shanghai Municipal Government 2010; Xinhua News Agency 2010a).

The current regulatory arrangements for Chinese electricity prices raise doubts about whether the cost of emissions-reduction policies is passed on to electricity consumers. For simplicity, it has been assumed here that electricity consumers do bear the cost of the analysed policies. However, the resulting estimates should be considered an upper bound on the actual change in electricity prices, abatement and consumption cost.

Low and high estimates of the Chinese retail electricity price — CNY 423/MWh and CNY 790/MWh — were used to place a range on demand-side abatement. These prices were based on data published by the State Electricity Regulatory Commission (SERC 2009), the official Chinese news service, and other sources.

- Xinhua News Agency (2010b) reported that, in December 2010, the retail price of electricity was about CNY 600/MWh. However, it was unclear whether this was an average across all regions and consumers.
- Data published by SERC (2009) indicate that the average residential electricity tariff in 2009 ranged from CNY 423/MWh in Hebei province to CNY 628/MWh in Guangdong province (SERC 2009).[12] Similarly, Lan (2010) reported a range of CNY 420/MWh in Qinghai to CNY 610/MWh in Guangdong.
- Xinhua News Agency (2009) reported that the residential tariff in Beijing was CNY 490/MWh. This was similar to the Beijing tariff of around CNY 480/MWh reported by Lan (2010) and Beijing International (2011), and CNY 473/MWh reported by SERC (2009).
- Chinese electricity prices are generally higher for non-residential customers. Xinhua News Agency (2009) reported that Beijing tariffs were around CNY 520/MWh for agricultural use, CNY 760/MWh for 'secondary industry',

12 This excludes Qinghai and Inner Mongolia, which were the only provinces that SERC (2009) reported as having an average price below CNY 400/MWh. Those provinces collectively accounted for less than 3 per cent of China's population in 2009 (CNBS 2009). Guangdong was the only province to have a price over CNY 600/MWh, but it accounted for around 7 per cent of China's population.

and CNY 790/MWh for 'commercial use'. Yiyu (2010) reported that the industrial tariff was CNY 560/MWh in 2009.

While there is some uncertainty associated with the total emissions and retail prices used here for the demand-side calculations, this is unlikely to have a notable effect on the results. As can be seen in table L.2, the estimated electricity-price increase (and hence emissions reduction and consumption cost) due to emissions-reduction policies is relatively small in percentage terms. This is due to the subsidy equivalents associated with the analysed policies being relatively insignificant when spread across all output.

Table L.2 **Estimated demand-side impacts of Chinese emissions-reduction policies**

	Units	*Low estimate*	*High estimate*
Inputs to calculations			
Carbon-price revenues and subsidy equivalents	CNY m	16 531	17 040
Jiangsu PV FITs	CNY m	516	516
Wind FITs and VAT exemption	CNY m	11 954	11 954
Biomass FITs	CNY m	4 061	4 570
Production[a]	TWh	3 446	3 446
Retail price[b]	CNY/MWh	790	423
Emissions[c]	Mt CO_2	3 075	3 075
Emissions intensity of displaced output[d]	t CO_2/MWh	0.8042	1.003
Demand elasticity		-0.2	-0.7
Estimation results			
Change in retail electricity price	%	0.6	1.2
Change in electricity consumption	%	-0.1	-0.8
Change in emissions	%	-0.1	-0.9
Consumption cost:[e]			
total amount	CNY m	10.1	71.1
per tonne of demand-side abatement[f]	CNY/t CO_2	3.0	2.5

a Electricity production in 2009 (EIA 2011k). **b** Range of retail prices reported by SERC (2009) and Xinhua News Agency (2009), as described in the main text. The highest price is used to generate the 'low estimate' results (and vice versa) because it minimises (maximises) the proportionate price change from a given amount of carbon-price revenues and subsidy equivalents. **c** 2009 emissions. Estimated by indexing up 2005 estimate of 2115 Mt from Malla (2009) by the percentage growth in output over 2005–2009 (output rose from 2370 TWh to 3446 TWh, an increase of around 45 per cent, according to EIA 2011k). **d** Emissions intensities are the lowest (new coal plants) and highest (national average 'operating margin' Clean Development Mechanism (CDM) projects) estimates used in this report's analysis of supply-side abatement. **e** Consumers' valuation of forgone electricity consumption, less the valuation of other goods that can be purchased with the diverted expenditure. **f** This amount is typically greater for the 'low estimate' because the consumption cost is spread across a smaller reduction in emissions.

Sources: EIA (2011k); Malla (2009); SERC (2009); Xinhua News Agency (2009); Productivity Commission estimates.

L.3 Germany

Three German policies were analysed for their demand-side impacts — the EU emissions trading scheme (ETS), Renewable Energy Sources Act (RES Act), and Combined Heat and Power Act (CHP Act). A more detailed description of each of these policies is provided in the analysis of German supply-side abatement in appendix F.

The combined carbon-price revenues and subsidy equivalents for the three policies was estimated to be in the range of €10 171–11 462 million. This range was derived as follows.

- The European Union ETS imposes an explicit carbon price on emissions. The revenue raised from the German electricity sector was estimated by multiplying an average permit price — €13.60 for April 2009 to March 2010 — by the number of permits required to cover 2009 electricity-sector emissions of 299 Mt CO_2. The resulting estimate was €4066 million.
- All renewable electricity generated in Germany was assumed to be induced by the RES Act feed-in tariffs. As a result, the estimated subsidy equivalent from the supply-side analysis was used here. This ranged from a low estimate of €5616 million to a high of €6832 million.
- The Commission concluded that only 57 per cent of electricity generation receiving CHP Act payments had been induced by the policy. Thus, the amount used here — €489 million — is greater than the subsidy equivalent estimated in the supply-side analysis (€279 million).

Data for other inputs to the calculations, such as electricity generation and prices, were sourced from Frontier Economics and Eurostat, as detailed in table L.3 below. The resulting estimates suggest that the analysed policies increased German electricity prices in the range of 12–14 per cent, and reduced emissions by between 3–19 per cent.

Table L.3 **Estimated demand-side impacts of German emissions-reduction policies**

	Units	*Low estimate*	*High estimate*
Inputs to calculations			
Carbon-price revenues and subsidy equivalents	€m	10 171	11 462
European Union ETS	€m	4 066	4 066
Renewable Energy Sources Act	€m	5 616	6 907
Combined Heat and Power Act	€m	489	489
Production[a]	TWh	593	593
Retail price[b]	€/MWh	156	156
Emissions[c]	Mt CO_2	299	299
Emissions intensity of displaced output[d]	t CO_2/MWh	0.53	1.09
Demand elasticity		-0.2	-0.7
Estimation results			
Change in retail electricity price	%	12	14
Change in electricity consumption	%	-2	-10
Change in emissions	%	-3	-19
Consumption cost:[e]			
total amount	€m	128	628
per tonne of demand-side abatement[f]	€/t CO_2	16	9

[a] Electricity production in 2009 (Frontier Economics, unpublished data). [b] Average of second-half 2009 retail prices for households (€229/MWh) and industry (€113/MWh) (Eurostat 2010), weighted by the share of each in final electricity demand (37 and 63 per cent respectively in 2008, based on Eurostat (2010) data on final energy consumption). [c] 2009 data from Frontier Economics (unpublished data). [d] Emissions intensities are the lowest (natural gas) and highest (lignite) estimates used in this report's analysis of supply-side abatement. [e] Consumers' valuation of forgone electricity consumption, less the valuation of other goods that can be purchased with the diverted expenditure. [f] This amount is typically greater for the 'low estimate' because the consumption cost is spread across a smaller reduction in emissions.

Sources: Eurostat (2010); Frontier Economics (unpublished data); Productivity Commission estimates.

L.4 Japan

Two of the Japanese policies covered in the analysis of supply-side abatement are taxpayer funded (appendix G), and so are not expected to lead to demand-side abatement.[13] The remaining policies analysed here are the Renewable Portfolio Standard, New Buyback Program for Solar Photovoltaic, and petroleum and coal tax. The combined carbon-price revenues and subsidy equivalents for these policies was estimated to be around ¥216 billion per annum. This was derived as follows.

[13] Policies excluded from the demand-side calculations are the national solar photovoltaic capital subsidies, and Tokyo solar photovoltaic capital subsidies.

- For the Renewable Portfolio Standard, the Commission assumed in its supply-side analysis that around 53 per cent of subsidised output was induced by the policy (4.6TWh out of 8.61TWh of subsidised output). Thus, the amount used here — ¥44 547 million — is greater than the subsidy equivalent estimated in the supply-side analysis (¥23 800 million).
- The New Buyback Program for Solar Photovoltaic has only been in place since November 2009. For this reason, the supply-side analysis only estimated a subsidy equivalent for the five-month period from 1 November 2009 to 31 March 2010 (¥6022 million). In contrast, the demand-side analysis here is based on an annualised estimate of the subsidy equivalent — ¥14 453 million — on the grounds that the policy is ongoing, and to ensure consistency with the annual amounts used for the other policies.
- Revenue raised by the petroleum and coal tax was derived by multiplying fuel-specific tax rates (estimated in the supply-side analysis) by the electricity generated by the relevant fuel.[14] This resulted in total tax revenue of ¥156 780 million.

Data for other inputs to the calculations, such as electricity production and retail prices, were sourced from the International Energy Agency (IEA) and United Nations Framework Convention on Climate Change (UNFCCC), as detailed in table L.4 below. The resulting estimates suggest that the analysed policies have a relatively small impact on Japanese electricity prices, and hence electricity consumption, emissions and consumption costs.

[14] The estimated tax rates were ¥0.16/kWh for gas-fired generation, ¥0.24/kWh for coal and ¥0.47/kWh for oil. In 2009, electricity generated from coal was 295 TWh, from gas 273 TWh, and from oil 90 TWh (IEA 2010d).

Table L.4 **Estimated demand-side impacts of Japanese emissions-reduction policies**

	Units	*Low estimate*	*High estimate*
Inputs to calculations			
Carbon-price revenues and subsidy equivalents	¥m	215 780	215 780
Renewable Portfolio Standard	¥m	44 547	44 547
New Buyback Program for Solar Photovoltaic[a]	¥m	14 453	14 453
Petroleum and Coal Tax	¥m	156 780	156 780
Production[b]	TWh	1 046	1 046
Retail price[c]	¥/MWh	21 300	14 760
Emissions[d]	Mt CO_2	396	396
Emissions intensity of displaced output[e]	t CO_2/MWh	0.439	0.574
Demand elasticity		-0.2	-0.7
Estimation results			
Change in retail electricity price	%	1.0	1.4
Change in electricity consumption	%	-0.2	-1.0
Change in emissions	%	-0.2	-1.5
Consumption cost:[f]			
total amount	¥m	211	1 081
per tonne of demand-side abatement[g]	¥/t CO_2	235	180

[a] Annualised estimate based on the subsidy equivalent of ¥6022 million estimated in this study's supply-side analysis for the five-month period from 1 November 2009 to 31 March 2010. [b] Electricity production in 2009 (IEA 2010d). [c] Average 2009 price reported by IEA (2010g) for residential customers (¥21 300/MWh) and industry (¥14 760/MWh). The highest price is used to generate the 'low estimate' results (and vice versa) because it minimises (maximises) the proportionate price change from a given amount of carbon-price revenues and subsidy equivalents. [d] 2008 data for electricity and heat sectors from UNFCCC (2011b). [e] Emissions intensities are those used for gas-fired (0.439 t CO_2/MWh) and oil-fired (0.574 t CO_2/MWh) generation in this report's analysis of supply-side abatement. [f] Consumers' valuation of forgone electricity consumption, less the valuation of other goods that can be purchased with the diverted expenditure. [g] This amount is typically greater for the 'low estimate' because the consumption cost is spread across a smaller reduction in emissions.

Sources: IEA (2010d, 2010g); UNFCCC (2011b); Productivity Commission estimates.

L.5 New Zealand

The key emissions-reduction policy affecting the electricity-generation sector is the New Zealand ETS, which has covered electricity generation since July 2010. While some industries have received free emissions permits to compensate for the impact of the ETS on asset values and competitiveness, this does not include electricity generators. The NZ Government has stated that free permits were not warranted for the energy sector because it is able to pass the cost of the ETS on to customers (NZME 2010).

Prior to its introduction, NZME (NZ Government) (2010) estimated that the ETS would raise electricity prices by NZ$0.01/kWh (NZ$10/MWh), or around 5 per cent for households. It was not stated whether this was the longer-term impact, or that expected in the short term while the ETS was being phased in. However, the Ministry for the Environment (NZ) (pers. comm., 23 May 2011) advised the Commission that 'the latter is more correct'. A transitional period applies until the end of 2012, during which the cost of the ETS is effectively capped at NZ$12.50/t CO_2-e emitted (NZME 2011c).

Given a permit price of NZ$12.50 per tonne and electricity-sector emissions of around 6 Mt CO_2 (2009 data reported by NZME 2011d), the ETS would raise about NZ$74 million from the electricity-generation sector. If all of this was passed on to electricity consumers, the Commission's illustrative estimates suggest that it would raise electricity prices by around 0.7–1.6 per cent for all consumers (table L.5).

Table L.5 **Estimated demand-side impacts of New Zealand emissions-reduction policies**

	Units	*Low estimate*	*High estimate*
Inputs to calculations			
Carbon-price revenues			
New Zealand ETS[a]	NZ$m	74	74
Production[b]	TWh	43	43
Retail price[c]	NZ$/MWh	243	111
Emissions[d]	Mt CO_2	6	6
Emissions intensity of displaced output[e]	t CO_2/MWh	0.52	0.52
Demand elasticity		-0.2	-0.7
Estimation results			
Change in retail electricity price	%	0.7	1.6
Change in electricity consumption	%	-0.1	-1.1
Change in emissions	%	-0.5	-4.0
Consumption cost:[f]			
total amount	NZ$m	0.1	0.4
per tonne of demand-side abatement[g]	NZ$/t CO_2	1.6	1.6

[a] Transitional cap of $12.50/t CO_2 multiplied by emissions from electricity generation (around 6 Mt CO_2). [b] Electricity production in 2009 (IEA 2010f). [c] Average price reported by IEA (2010g) for residential customers in 2009 (NZ$243/MWh) and industry in second and third quarters of 2009 (NZ$111/MWh). The highest price is used to generate the 'low estimate' results (and vice versa) because it minimises (maximises) the proportionate price change from a given amount of carbon-price revenues and subsidy equivalents. [d] 2009 emissions reported by NZME (2011d) for public electricity and heat production. [e] Emissions intensity of the marginal generator used by Bartleet et al. (2010). [f] Consumers' valuation of forgone electricity consumption, less the valuation of other goods that can be purchased with the diverted expenditure. [g] This amount is typically greater for the 'low estimate' because the consumption cost is spread across a smaller reduction in emissions.

Sources: Bartleet et al. (2010); IEA (2010f, 2010g); NZME (2011c); Productivity Commission estimates.

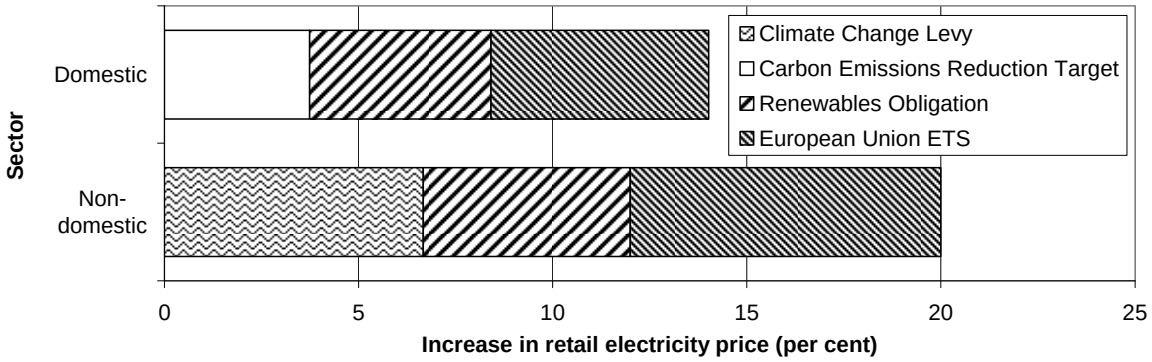
L.6 South Korea

All of the (six) South Korean policies included in the analysis of supply-side abatement are funded by taxpayers (appendix I). Hence, the Commission did not estimate demand-side abatement or consumption costs associated with those policies.

L.7 United Kingdom

The UK Government has estimated that, in 2010, its climate change and energy policies increased electricity prices by 14 per cent for domestic consumers, and 20 per cent for non-domestic consumers (DECC (UK) 2010d). Virtually all of the price impacts were attributed to just four policies — the Climate Change Levy, Carbon Emissions Reduction Target, Renewables Obligation, and European Union ETS (figure L.1).

Figure L.1 **UK Government estimates of abatement policy impacts on electricity prices, 2010**



Source: DECC (UK) (2010d).

Given the above predicted price impacts, the Commission estimates that the policies have reduced UK electricity consumption by between 3–12 per cent, and emissions by 3–19 per cent (table L.6).

Table L.6 **Estimated demand-side impacts of UK emissions-reduction policies**

	Units	*Low estimate*	*High estimate*
Inputs to calculations			
Production[a]	TWh	372	372
Retail price[b]	£/MWh	102	102
Emissions[c]	Mt CO_2	151	151
Emissions intensity of displaced output[d]	t CO_2/MWh	0.3939	0.6900
Demand elasticity		-0.2	-0.7
Estimation results			
Change in retail electricity price[e]	%	17	17
Change in electricity consumption	%	-3	-12
Change in emissions	%	-3	-19
Consumption cost:[f]			
total amount	£m	99	382
per tonne of demand-side abatement[g]	£/t CO_2	19	11

[a] Electricity production in 2009 (DECC (UK) 2010a). [b] Weighted average of 2010 retail prices for domestic (£122/MWh) and non-domestic (£90/MWh) consumers (DECC (UK) 2010d), with weights based on their shares of final electricity demand (38 and 62 per cent respectively in 2009, according to DECC (UK) 2010a). [c] 2009 data from DECC (UK) (2009). [d] Emissions intensities are the lowest and highest estimates used previously in this report's analysis of supply-side abatement. [e] Based on DECC (UK) (2010d) estimate that emissions-reduction policies caused retail prices to rise by £15/MWh in 2010 for both domestic and non-domestic customers. [f] Consumers' valuation of forgone electricity consumption, less the valuation of other goods that can be purchased with the diverted expenditure. [g] This amount is typically greater for the 'low estimate' because the consumption cost is spread across a smaller reduction in emissions.

Sources: DECC (UK) (2009, 2010a, 2010d); Productivity Commission estimates.

L.8 United States

Most of the US policies covered in the analysis of supply-side abatement are taxpayer funded, and so are not expected to lead to demand-side abatement (appendix K).[15] The remaining policies analysed here are the Regional Greenhouse Gas Initiative (RGGI) and Renewable Portfolio Standards (RPS). The combined carbon-price revenues and subsidy equivalents for these policies was estimated to be between US$742 million and US$946 million. The calculations used to derive this range are outlined below.

[15] Policies excluded from the demand-side calculations are the Californian Emerging Renewable Program, Californian New Solar Homes Partnership, Californian Solar Initiative, Renewable Electricity Production Tax Credits, Self Generation Incentive Program, and Treasury Grants.

Regional Greenhouse Gas Initiative

The Commission concluded that the RGGI induces no supply-side abatement because the price of emissions permits (termed 'allowances') has been too low to induce fuel switching (appendix K). However, the cost borne by generators in purchasing permits could raise electricity prices, and thus induce some demand-side abatement.

New RGGI permits are sold in quarterly auctions, and existing ones can be purchased in a secondary market. The vast majority of permits have been purchased by generators at an auction. For example, in 2010, around 140 million permits were auctioned for the current control period (emissions occurring in the period 2009–2011) (RGGI Inc. 2011a). In contrast, only about 4 million such permits were exchanged in the secondary market in 2010 (Potomac Economics 2011). The Commission has therefore used auction prices to estimate demand-side abatement.

To date, there have been eleven quarterly auctions for RGGI permits (held from September 2008 to March 2011). The average permit price received at individual auctions has ranged from US$1.86 (September and December 2010 auctions) to US$3.51 (March 2009).[16] One of these permits has to be surrendered for each US (short) ton of CO_2 emitted during the period 2009–2011. On this basis, and given that 1 US ton equals 0.907184 metric tonnes, the price range for auctioned permits can be re-expressed as US$2.05–3.87/tonne CO_2. This price range was multiplied by 2009 electricity-sector emissions in the relevant states to derive a range for the annual cost to generators of the RGGI scheme.

In 2009, electricity generators in the ten RGGI states emitted 123.7 million US (short) tons (NYSERDA 2010b), which equated to around 112 Mt CO_2. This was well below the annual cap set by RGGI of 188 million US (short) tons (RGGI Inc. 2011b), or around 171 Mt CO_2. The Commission used actual emissions (112 Mt CO_2) in its demand-side calculations for the RGGI scheme. On this basis, the cost of the RGGI scheme to generators was estimated to be between US$230–434 million.

Renewable Portfolio Standards

As noted in the analysis of supply-side abatement, it was not possible to use the price of renewable energy certificates (RECs) to estimate the cost of each state's RPS. The necessary price data were often unavailable, and there appears to be

16 Excludes permits for post-2011 emissions.

limited trading of RECs because RPS requirements are often met through direct ownership of renewable capacity or bilateral contracts with renewable generators.

The supply-side analysis instead estimated the share of renewable generation induced by the RPS, and calculated an associated cost based on available financial information. This resulted in an estimated subsidy equivalent of US$512 million for the nine states analysed.[17] This amount is also used here for the demand-side calculations, on the assumption that the RPS only increases retail electricity prices to the extent that it induces additional generation of renewables. That is, no additional cost was attached to renewables generation that would have occurred without the RPS.

Data for other inputs to the calculations, such as electricity production and prices, were sourced from the IEA and US government agencies, as detailed in table L.7 below. The resulting estimates suggest that the analysed policies have a negligible impact on US electricity prices and hence result in little demand-side abatement in percentage terms.

[17] California, Colorado, Connecticut, Illinois, Massachusetts, Minnesota, Montana, New Mexico and New York. Among the remaining 41 states, 14 do not have an RPS, 7 have an RPS that sets an aspirational target with no compulsion for generators to achieve the target, 3 have an RPS that sets a relatively low target compared to pre-existing renewable generation, and 7 have an RPS that commenced after 2010.

Table L.7 **Estimated demand-side impacts of US emissions-reduction policies**

	Units	*Low estimate*	*High estimate*
Inputs to calculations			
Carbon-price revenues and subsidy equivalents	US$m	742	946
Regional Greenhouse Gas Initiative	US$m	230	434
Renewable Portfolio Standards	US$m	512	512
Production[a]	TWh	3 953	3 953
Retail price[b]	US$/MWh	116	68
Emissions[c]			
All states	Mt CO_2	2 270	2 270
RGGI states	Mt CO_2	112	112
Emissions intensity of displaced output[d]	t CO_2/MWh	0.406	0.908
Demand elasticity		-0.2	-0.7
Estimation results			
Change in retail electricity price	%	0.2	0.4
Change in electricity consumption	%	-0.03	-0.2
Change in emissions	%	-0.02	-0.4
Consumption cost:[e]			
total amount	US$m	0.1	1.2
per tonne of demand-side abatement[f]	US$/t CO_2	0.2	0.1

a Electricity production in 2009 (EIA 2011k). **b** Average 2009 price reported by IEA (2010g) for residential customers (US$116/MWh) and industry (US$68/MWh). The highest price is used to generate the 'low estimate' results (and vice-versa) because it minimises (maximises) the proportionate price change from a given amount of carbon-price revenues and subsidy equivalents. **c** 2009 emissions. National data from EIA (2011h). Data for RGGI states (California, Colorado, Connecticut, Illinois, Massachusetts, Minnesota, Montana, New Mexico and New York) from NYSERDA (2010b). **d** Emissions intensities are the lowest (0.406 t CO_2/MWh for California gas) and highest (0.908 t CO_2/MWh for mid-west coal and gas) estimates used in this report's analysis of supply-side abatement. **e** Consumers' valuation of forgone electricity consumption, less the valuation of other goods that can be purchased with the diverted expenditure. **f** This amount is typically greater for the 'low estimate' because the consumption cost is spread across a smaller reduction in emissions.

Sources: EIA (2011h, 2011k); IEA (2010g); NYSERDA (2010b); Productivity Commission estimates.

M Road transport fuels

This appendix provides information on the use and characteristics of transport fuels used to support the Commission's analysis of biofuel policies and fuel taxes. It provides a brief overview of road transport fuel consumption and greenhouse gas emissions by study country. It also explains the Commission's use of life-cycle assessment for greenhouse gas emissions from transport fuels and details the specific estimates used in the analysis.

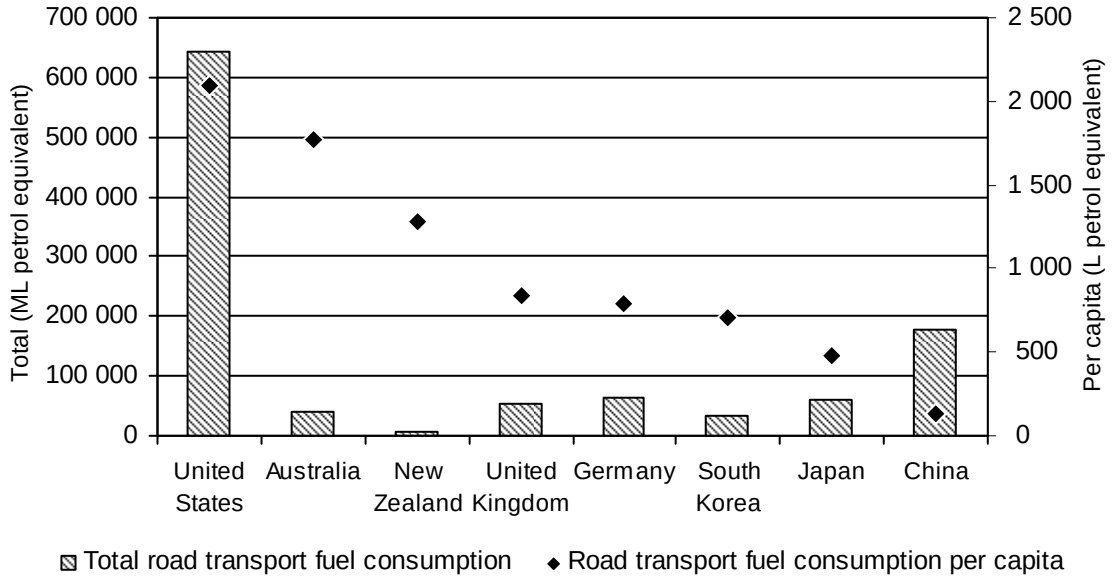
M.1 Transport fuel use

An understanding of the volume and composition of road transport fuel consumption in each of the study countries provides useful context for the analysis of fuel taxes and biofuel policies. Figure M.1 below shows total consumption of road transport fuel and fuel consumption per-capita in each of the study countries during the year of analysis. In absolute terms, the United States was by far the largest consumer of road transport fuel, using more fuel than all the other study countries combined.

On a per-capita basis, road transport fuel consumption varied greatly by study country. Again, the United States was the largest consumer, but this time followed closely by Australia and New Zealand. Per-capita fuel consumption was much lower in the European study countries and lower still in the developed Asian study countries. Despite relatively high total fuel consumption, China's per-capita figure was by far the lowest, at just seven per cent of the value for Australia. Differences in per-capita fuel consumption are attributable to variation in a number of factors including income per-capita, the spatial distribution of the population and economic activity, the availability of modal substitutes and the fuel-efficiency of vehicles.

Figure M.1 **Fuel consumption by country**

Total and per-capita, 2009-2010[a]

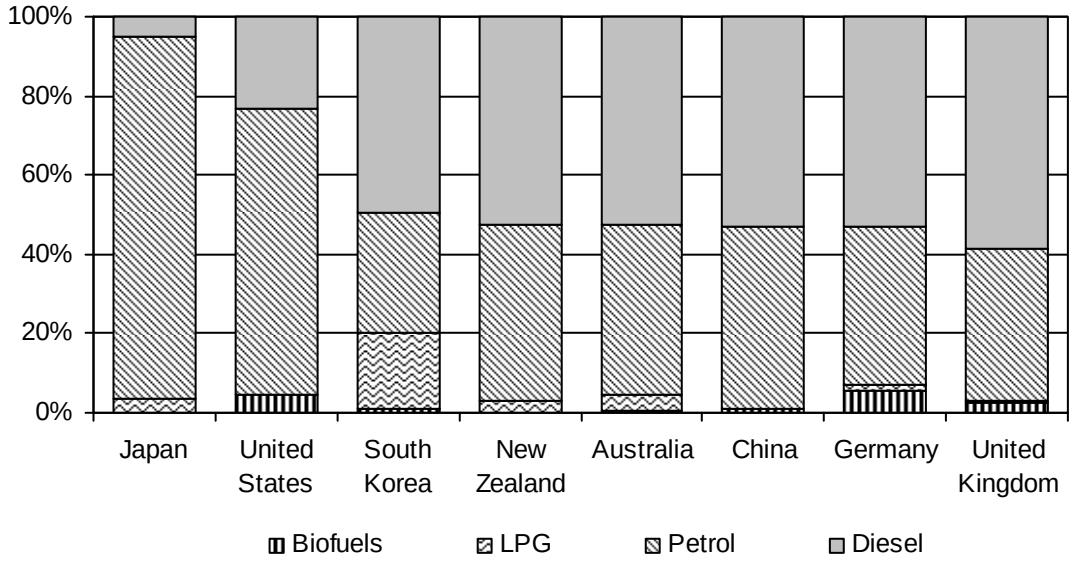


[a] Fuel consumption figures for each country reflect the annual estimate in the year of analysis for biofuel policies (appendix N).

Sources: UN (2011); Appendix N; Productivity Commission estimates.

The composition of road transport fuels consumed in each country is also instructive when considering the impact of transport policies. In the United States and Japan, petrol was the most commonly used fuel, whereas in all other study countries, diesel was the most commonly used fuel during the period of analysis (figure M.2). Consumption of liquefied petroleum gas (LPG) was highest in South Korea both in absolute terms and as a proportion of total fuel consumption. Japan, Australia and New Zealand were also significant consumers of LPG as a proportion of total fuel consumption. Consumption of biofuels (biodiesel, ethanol and vegetable oil) accounted for only a small share of total fuel consumption in each of the study countries.

Figure M.2 **Composition of fuel consumption by country**
2009-2010[a]

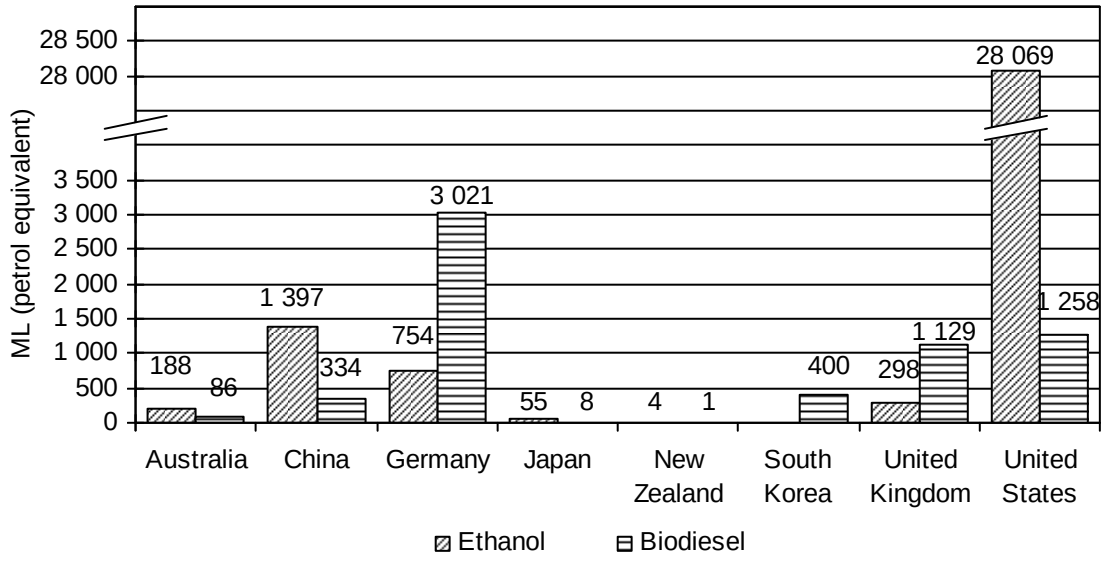


[a] Fuel consumption figures for each country reflect the annual estimate in the year of analysis for biofuel policies (appendix N).

Sources: Appendix N; Productivity Commission estimates.

Given that biofuel policies are a focus of this study, a closer look at consumption of biofuels by country is warranted. Figure M.3 shows total consumption of ethanol and biodiesel in each of the study countries during the year of analysis. Reflecting high levels of government support, the United States was by far the largest consumer of biofuel. US ethanol consumption was equal to more than ten times total consumption in all other study countries combined. Other major ethanol consumers included China and Germany. Germany was also the largest consumer of biodiesel among study countries, with the United States and the United Kingdom also significant consumers.

Figure M.3 **Biofuel consumption by country**[a]
2009-2010[b]



a The biodiesel figure for Germany includes pure vegetable oil used as a road transport fuel. **b** Fuel consumption figures for each country reflect the annual estimate in the year of analysis for biofuel policies (appendix N).

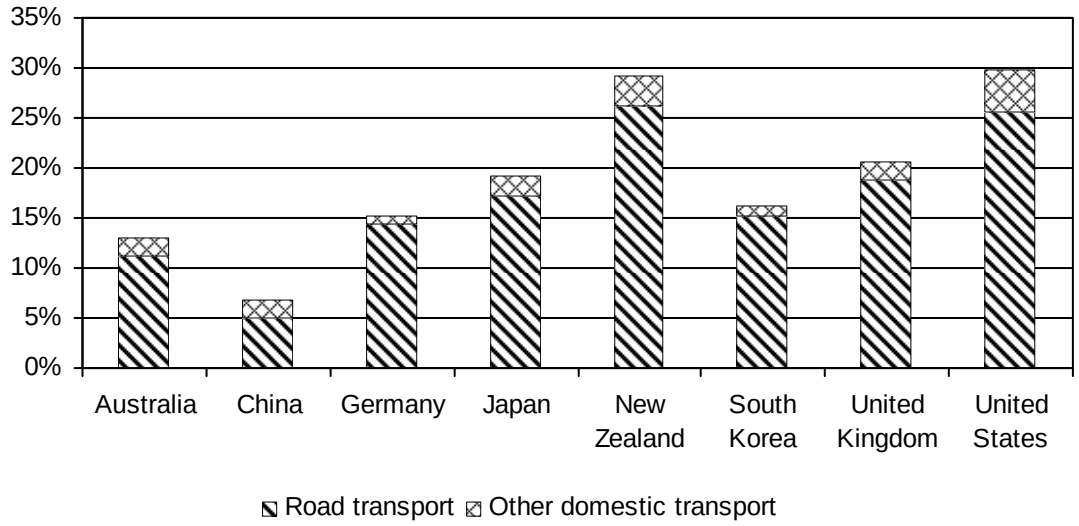
Sources: Appendix N; Productivity Commission estimates.

M.2 Emissions from transport fuel

Road transport fuels are a major source of greenhouse gas emissions. Figure M.4 shows the proportion of greenhouse gas emissions attributable to road transport in each of the study countries during 2008. For every country except China, road transport emissions represented at least 10 per cent of total greenhouse gas emissions and in some countries greater than 20 per cent. Furthermore, while China's road transport emissions were only about five per cent of total emissions, they were growing strongly. Between 1990 and 2008, road transport emissions increased by more than 400 per cent in China (IEA 2010a).

Figure M.4 **Road transport greenhouse gas emissions as a percentage of total national emissions[a,b]**

2008 (or most recent year available)



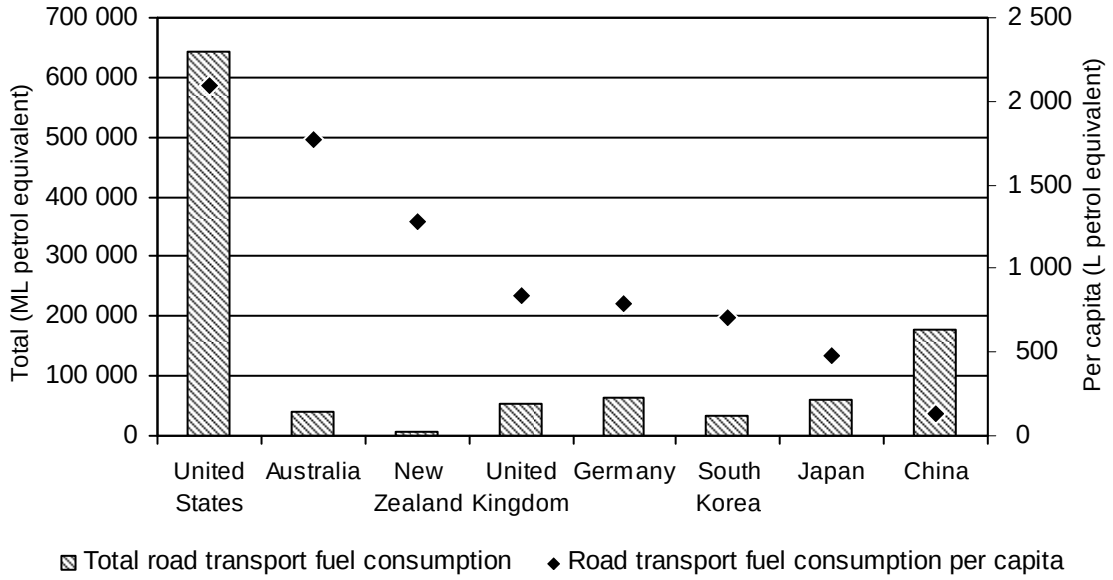
a 'Other domestic transport' includes emissions from fuel used for domestic civil aviation, railways, domestic water-borne navigation, pipeline transport, fishing, off-road transport and other non-specified domestic transport emissions. It excludes emissions from fuel sold for use in any aircraft or marine vessel engaged in international transport. **b** As China and South Korea do not have official reporting obligations under the Kyoto Protocol, national emissions are 2007 estimates (WRI 2010) and exclude emissions from land-use change and forestry. Road transport and other domestic transport emissions for China and South Korea are 2008 estimates from IEA (2010a).

Sources: WRI (2010); IEA (2010a); UNFCCC (2011a).

To provide context for the above numbers, figure M.5 shows greenhouse gas emissions from road transport in absolute and per-capita terms. Reflecting high levels of fuel consumption, road transport emissions from the United States were the largest on either basis. While China's emissions were the next largest in absolute terms, its per-capita emissions were considerably lower than in any other study countries.

Figure M.5 also illustrates significant variation in per-capita emissions between the other study countries. Road transport emissions per-capita were between 50 and 100 per cent higher in Australia and New Zealand than in Korea, Germany, Japan and the United Kingdom. These differences are mostly attributable to variation in fuel consumption per-capita, but the composition of transport fuels also plays a role as the emissions intensity of some fuels is greater than others.

Figure M.5 **Greenhouse gas emissions from road transport**
2008, total and per-capita



Sources: IEA (2010a); UN (2011).

M.3 Using life-cycle emissions estimates

The emissions intensity of different fuel types was a crucial input to the Commission's estimates of abatement from fuel taxes and biofuel policies. In order to provide an adequate picture of abatement, the Commission has used 'life-cycle' assessments (LCA) of greenhouse gas emissions. This section explains the purpose of LCA and why it was used for transport sector policies. It also discusses the potential for differences in LCA estimates and provides details of the LCA estimates used by the Commission.

What is life-cycle assessment?

LCA is a technique used to assess the environmental impacts of a product or activity. It involves compiling an inventory of relevant energy and material inputs and environmental releases and evaluating their potential environmental impact. A life-cycle assessment of the greenhouse gas emissions associated with a product involves assessing all of the emissions attributable to the product beginning with the production or extraction of raw materials and ending with the product's disposal. Life-cycle assessment of greenhouse gas emissions from transport fuel is often described as 'well to wheels' analysis because it takes into account both 'upstream'

emissions (that is, ‘well to tank’) and ‘downstream’ emissions (that is, ‘tank to wheels’).

Upstream emissions refer to all those emissions taking place during the production of the fuel up until delivery to the end user. For example, major sources of upstream emissions from diesel include fugitive emissions during oil exploration, emissions from flaring during oil production, emissions from electricity usage during the production of oil and its refinement into diesel, and all emissions from the transport of diesel and its precedents. Downstream emissions refer to the emissions from fuel combustion by the end user.

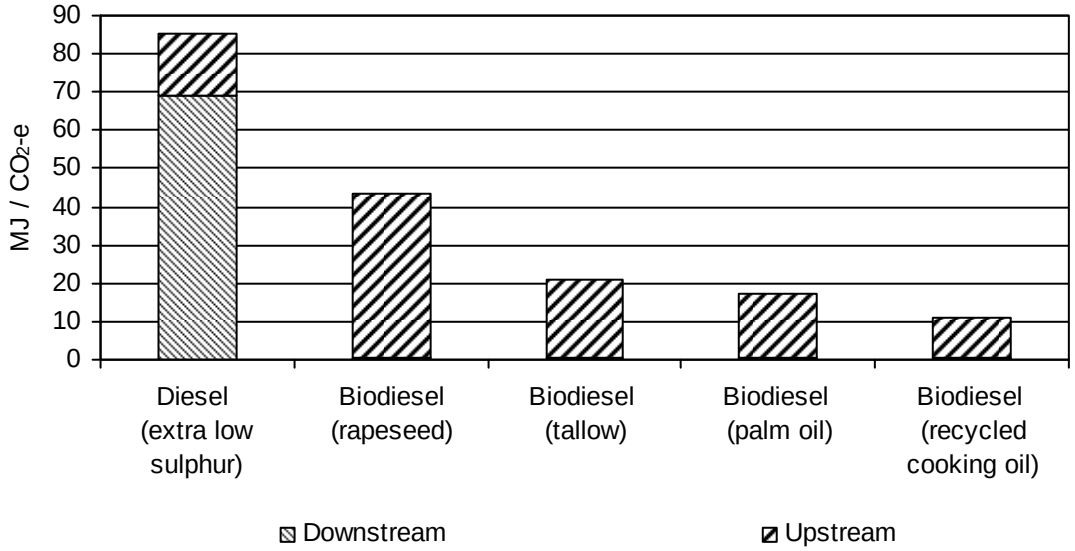
Why use life-cycle assessments?

Life-cycle assessment of greenhouse gas emissions from transport fuels is important to adequately account for the abatement achieved by road transport policies. This is particularly true where policies impact consumption of biofuels relative to conventional fuels because the emissions profiles of the two fuel types differ significantly.

Both conventional fuels and biofuels emit carbon dioxide through fuel combustion. However, conventional fuels use crude oil as a feedstock whereas biofuels use plant and animal products. The carbon content of crude oil is stored underground for millions of years prior to its extraction. By contrast, the carbon content of plants and animals comes from the sequestration of carbon dioxide from the atmosphere during their lifetime (Beer, Grant and Campbell 2007). The emissions from these processes are accounted for differently. Current international greenhouse gas accounting rules include carbon dioxide emissions from the combustion of conventional fuels but assign a value of zero to the carbon dioxide emissions from the combustion of biofuels (Australian Government 2008).

While the downstream emissions of biofuels are therefore much lower than conventional fuels, the upstream emissions of biofuels are often much higher because the production and conversion of biofuel feedstocks can be quite emissions intensive. To illustrate this point, figure M.6 contrasts the upstream and downstream emissions of diesel with biodiesel produced from various feedstocks in Australia. Downstream emissions constitute more than 80 per cent of life-cycle diesel emissions, but less than five per cent of life-cycle biodiesel emissions. Thus, if only downstream emissions were considered, abatement estimates would be biased in favour of biofuels.

Figure M.6 **Comparing upstream and downstream emissions**
Diesel and biodiesels by feedstock, Australia



Source: Beer, Grant and Campbell (2007).

Life-cycle assessment of greenhouse gas emissions has not been used in analysis of policies in the electricity sector. The Commission's abatement estimates for the electricity sector are instead based on downstream emissions only (that is, emissions from the combustion of fuels to generate electricity). Upstream emissions in the electricity sector were not taken into account due to limited data availability and uncertainty about the scope of these emissions. The exclusion of upstream emissions from the analysis of the electricity sector is unlikely to have a significant effect on the ranking of generation technologies because downstream emissions from most conventional forms of electricity generation are significantly larger than the upstream emissions of even the most emissions-intensive renewable energy technologies (Weisser 2007). It is important to note, however, that because transport emissions were assessed on a different basis to electricity emissions, estimates for abatement and implicit abatement subsidies for policies in the transport sector and the electricity sector are not strictly comparable.

Life-cycle assessment of greenhouse gas emissions in the transport sector also has important implications for the interpretation of results. Most estimates of road transport sector greenhouse gas emissions, including those provided in the previous section, only include downstream emissions. Figures on total road transport emissions indicate the scale of abatement achieved in different study countries, but such comparisons are only illustrative as the abatement estimates also include reductions in emissions associated with other sectors.

Further to this, transport fuels and fuel feedstocks are often imported by study countries. Because LCA of emissions takes into account emissions attributable to the production as well as the consumption of these fuels, abatement estimates may take into account the effect of a policy on emissions occurring beyond a country's borders. Given that emissions occurring in all countries contribute equally to climate change, inclusion of these emissions was appropriate but also noteworthy.

Choosing life-cycle assessments

There is a significant body of literature on the emissions intensity of transport fuels. However, the estimates for any given fuel type vary significantly by study and the volume of available literature varies greatly from country to country.

The Commission's approach to choosing estimates of life-cycle emissions from fuels has been to source government publications wherever possible. Estimates for Australia, Germany, Japan, New Zealand, the United Kingdom and the United States relied on the use of life-cycle emissions estimates published by government departments, associated government agencies or government-employed consultants.

Where estimates from official government sources were unavailable or not sufficiently detailed, refereed academic literature was also used. Country-specific studies were an important supplementary source of estimates for China. In the case of South Korea, where neither government estimates nor country-specific estimates from academic literature were available, the Commission used a combination of emissions estimates for Japan and default estimates from the Renewable Fuel Agency's (RFA) (UK) Carbon Calculator (box M.1). In all cases where sources other than government estimates were used or where government estimates were lacking in sufficient detail to ensure accurate results, the Commission conducted sensitivity analysis to show the effect of using other estimates of life-cycle emissions intensities.

Explaining differences in LCA estimates

Estimates of life-cycle emissions for transport fuels consumed in study countries vary significantly even when comparing the same type of fuel. There are a large number of variables relating to the production and consumption of any given fuel that can affect the final estimate of greenhouse gas emissions intensity. As the results in the following section illustrate, the potential for differences between countries and feedstocks is greatest for biofuels because the steps in the life-cycle process vary greatly.

Box M.1 Using the RFA's Carbon Calculator for South Korean estimates

The Carbon Calculator is a software program developed by the United Kingdom's Renewable Fuel Agency. The program assists UK fossil fuel and biofuel suppliers to prepare reports on the volume and emissions intensity of biofuels sold to meet reporting requirements under the United Kingdom's Renewable Transport Fuels Obligation.

The Carbon Calculator uses default values to provide estimates of the emissions intensity of different fuel life cycles. Fuel suppliers can alter default values in the Carbon Calculator and improve the accuracy of an estimate by including information specific to the batch of biofuel being reported. However, the Carbon Calculator is designed so that fuel suppliers can still meet reporting requirements where little is known about the origin, feedstock or means of manufacture of the biofuel being supplied. Default values are conservative in assuming relatively high emissions intensities so that suppliers are encouraged to provide additional information (RFA (UK) 2010c). Default emissions intensity values are available not just for biofuel produced in the United Kingdom but also for biofuel imported from a number of other countries using various feedstocks.

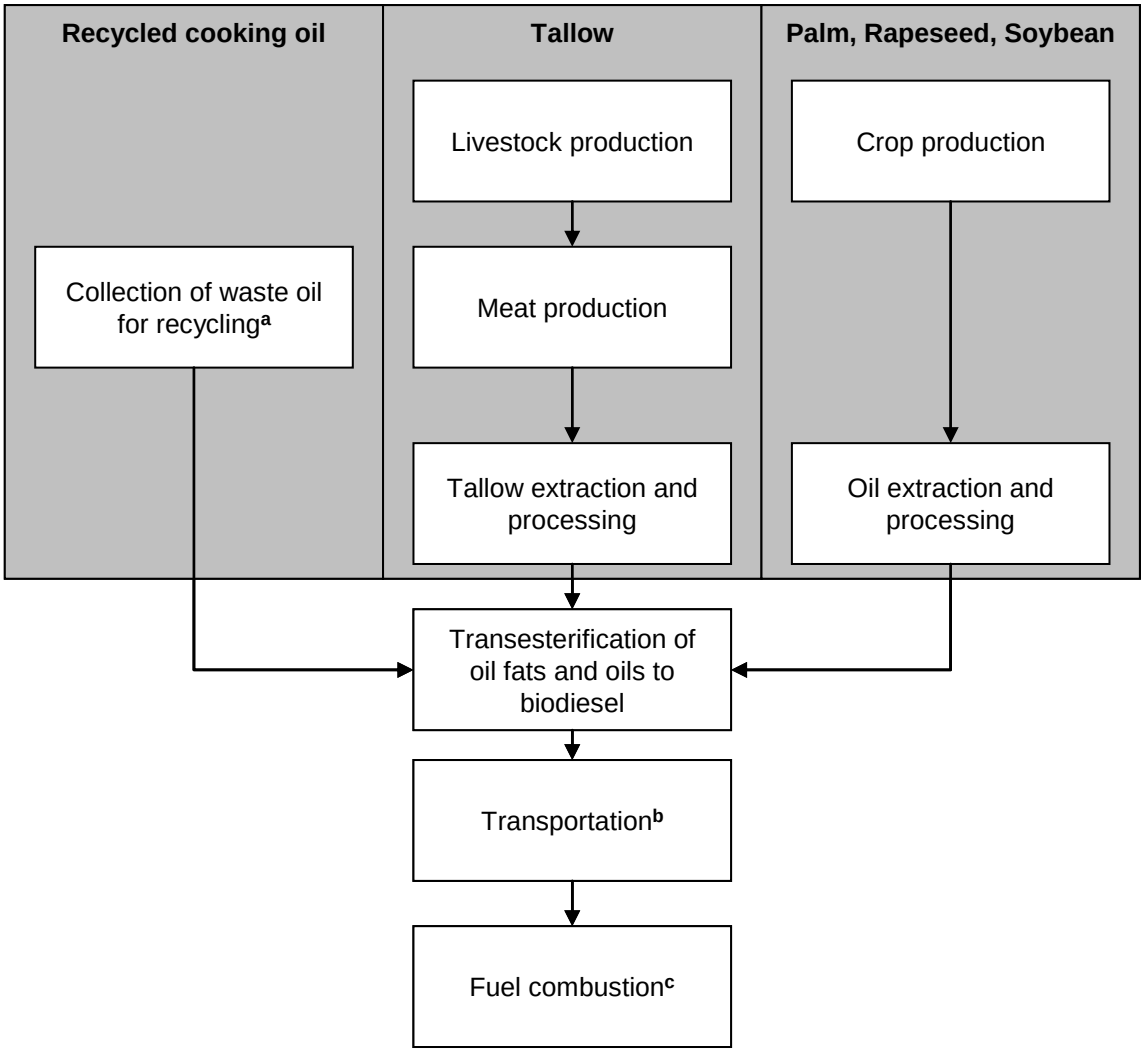
In the absence of estimates from government sources or refereed academic literature, the Commission used the Carbon Calculator to estimate the life-cycle emissions intensity of South Korean biodiesel produced with palm oil imported from Indonesia and Malaysia and soybean oil imported from Argentina and Brazil. Because the Carbon Calculator is designed to provide estimates for biodiesel imported and consumed in the United Kingdom, the Commission altered the default values in the Carbon Calculator to reflect differences between South Korea and the United Kingdom. In particular, the default estimates were adjusted to reflect differences in shipping distances, the emissions intensity of electricity generation and the emissions intensity of road transport. In all other respects, the default values were used.

Source: RFA (UK) (2010c).

Figure M.7 provides a stylised example of the components of a product life cycle for various types of biodiesel. In each step in the life cycle, greenhouse gas emissions are generated. The emissions intensity of any given step in the process is determined by several interacting variables.

The most emissions intensive step in the process tends to be the first step — the production or collection of the raw material. For biodiesel produced from plants such as rapeseed, this means cultivation of the feedstock crop. The emissions intensity of crop production depends on a variety of factors including previous land use, the type of crop grown and its yield, and the type and rate of fertiliser and pesticide applied.

Figure M.7 **Biodiesel life cycle by feedstock**



a The general approach to estimating life-cycle emissions for biofuels produced from waste feedstocks (such as cooking oil) is to not include emissions associated with the production of the waste product. Consequently, the first step in the life-cycle process of biodiesel produced from recycled cooking oil is the collection of waste oil. **b** Transportation is pictured here as occurring only between the biodiesel production facility and the fuel pump but transportation and associated emissions actually take place between each step in the process. **c** Due to sequestration by feedstocks, carbon dioxide emissions due to biodiesel combustion are usually assigned a value of zero.

Source: Productivity Commission based on Beer et al. (2005).

Depending on the feedstock used, later steps in the process may involve extraction and processing of raw materials into suitable feedstocks before conversion into biodiesel via a chemical process known as 'transesterification'. Both the processing of raw materials and the conversion of feedstocks into biodiesel involve further greenhouse gas emissions that vary according to factors such as the process yield, the energy intensity of the extraction and conversion processes and the emissions intensity of energy used. Additional greenhouse gas emissions occur during the transport of raw materials, feedstocks and final products, and these emissions are

affected by the distance travelled and the emissions intensity of the transport mode used.

Due to the wide variety of variables at play, it is possible that biodiesel produced in two different plants (or two different countries) using the same feedstock can have significantly different overall emissions intensities. Although biodiesel has been used as the example, similar differences in variables affect the emissions from each step in the life cycle of all types of biofuel, and to a lesser extent, conventional fuels. Differences in these variables account for most of the variation in emissions intensity estimates between countries within and across each fuel type.

However, even in cases where all of the key variables affecting the emissions intensity of a fuel are the same there is still the potential for estimates to somewhat diverge due to methodological differences in accounting for emissions. While methodological differences are limited due to the adoption of international standards for life-cycle assessment (ISO 2006), some differences are inevitable given the wide variety of sources used for estimates in different countries. Two key methodological differences with the potential to affect results relate to the inclusion or exclusion of emissions due to direct land-use change and the treatment of emissions where biofuels are produced from coproducts or byproducts.

The inclusion of direct land-use change can have significant impacts on emissions intensity estimates, particularly for biofuels (box M.2). Assessing emissions due to land-use change is complex and information intensive. Consequently, estimates reported by government agencies tend not to take into account changes in land use. The United Kingdom is the exception — the strict reporting guidelines under the Renewable Transport Fuels Obligation require that direct land-use change be taken into account if previous land use is known. However, in UK fiscal year 2009, previous land use was reported by UK biofuel suppliers as either unknown or cropland for all ethanol and biodiesel not based on byproducts. Consequently, inclusion of land-use change emissions for the United Kingdom is not likely to have significantly biased abatement estimates.

The second key methodological difference relates to the treatment of emissions associated with biofuels produced from coproducts and byproducts. Biofuel feedstocks produced as coproducts or byproducts include tallow, rapeseed oil, sugar cane and wheat starch. Methodological differences occur for these feedstocks because when more than one product is produced from the same process, the emissions resulting from that process need to somehow be shared between the products.

Box M.2 **Fuel emissions and direct land-use change**

Direct land-use change refers to a change in management practices on a certain type of land cover (Garnaut 2008). An example of direct land-use change is the clearing of forest so that land can be used for agricultural crops to produce ethanol. Changes in land use can have significant immediate impacts on greenhouse gas emissions by removing carbon dioxide sequestered in vegetation and soil. Whether or not land-use changes are taken into account can therefore significantly affect estimates of the emissions intensity of a given fuel.

A case in point is land-use change due to biodiesel produced using palm oil. Beer, Grant and Campbell (2007) estimate the emissions intensity of biodiesel-produced palm oil under three scenarios:

1. An existing plantation of palm oil in Malaysia (that is, no land-use change).
2. A new plantation of palm oil on cleared rainforest in Malaysia.
3. A new plantation of palm oil on cleared peat swamp forest in Indonesia.

In each scenario, emissions from land-use change are shared over fifty years of production from the palm oil plantation. Under the first scenario where there is no land-use change, the emissions intensity of biodiesel produced from palm oil is 79 per cent lower than that of regular diesel. However, under the second scenario the emissions intensity of biodiesel produced with palm oil is almost ten times higher than diesel and, under the third scenario, more than 20 times higher after taking into account emissions from land-use change.

In most cases, emissions from direct land-use change are unlikely to be this significant as a large share of biofuel is produced on existing cropland. Nonetheless, it is important to recognise the potential impact of land-use change on emissions estimates.

Sources: Beer, Grant and Campbell (2007); Garnaut (2008).

Some studies allocate emissions based on the estimated economic value of each product. Others use a process known as ‘system boundary expansion’ to take into account potential flow-on effects of using the feedstock to produce biofuel rather than its traditional use. For example, if tallow was traditionally used to produce soap and is now diverted to make biodiesel, the emissions associated with producing vegetable oil as an alternative input to soap production would also need to be taken into account (Beer et al. 2005). While, ‘system boundary expansion’ is the preferred approach under international standards (ISO 2006), it is also more information intensive. Consequently, studies in different countries have adopted different approaches and estimates used by the Commission are therefore based on a mix of approaches.

M.4 Fuel properties and life-cycle emissions intensities

The following tables show the energy content, density and emissions intensity of fuels that have been used for each of the study countries. The emissions intensity of each fuel is reported per megajoule (MJ) and 'litres of petrol equivalent' (converted using the energy content values reported for each country). In addition, several other conversion rates were used for units of energy and volume (table M.1).

Table M.1 **General conversion rates**

Conversion	*Value*
Litres per US gallon	3.7854
US gallons per barrel	42
MJ per million British thermal units	1 055
MJ per million calories	4.1868
MJ per kWh	3.6

For China and South Korea, low, central and high estimates are provided for the emissions intensity of some fuels. These estimates are used for the sensitivity analysis in appendix N. In the case of China these figures reflect variation in reported estimates. In the case of South Korea, the Commission has calculated high and low estimates that are, respectively, 10 per cent above and below the central figure to reflect uncertainty around the accuracy of the central estimate. Where not otherwise stated in the tables, feedstocks are domestically produced.

Table M.2 **Fuel properties and emissions intensities**[a]

Australia

Fuel type	*Feedstock*	*Energy content*	*Density*	*Life-cycle emissions intensity*[b]	*Life-cycle emissions intensity*
		MJ/L	kg/L	g CO_2-e/MJ	g CO_2-e/L petrol equivalent
Petrol	Petroleum	34.2	0.74	88.4	3 023
Diesel	Petroleum	38.6	0.85	85.5	2 924
LPG	Petroleum	25.7	0.53	76.4	2 613
Ethanol		23.4	0.79	..	..
	Molasses	..	..	55.7	1 904
	Sorghum	..	..	61.9	2 115
	Wheat starch	..	..	55.7	1 904
Biodiesel		32.8[c]	0.89[d]	..	..
	Rapeseed oil	..	..	43.3	1 481
	Recycled cooking oil	..	..	10.9	373
	Soybean oil	..	..	32.6	1 115
	Tallow	..	..	20.9	715

a All energy content and density figures are from ABARES (2011) except for biodiesel. The energy density of biodiesel is assumed to be the same as the United States. The energy content of biodiesel was estimated by the Commission assuming 36 800 MJ/t (IEA 2010e). **b** Emissions intensities for extra low sulphur diesel and biodiesel produced from all feedstocks except soybean oil are from Beer, Grant and Campbell (2007). Emissions intensities for petrol, biodiesel produced from soybean oil, and ethanol produced from all feedstocks are from CSIRO, ABARE and BTRE (2003). The emissions intensity for LPG (Autogas) is from Beer et al. (2005). **..** Not applicable

Sources: Beer et al. (2005); Beer, Grant and Campbell (2007); CSIRO, ABARE and BTRE (2003); IEA (2010e).

Table M.3 **Fuel properties and emissions intensities**[a]

China

Fuel type	*Feedstock*	*Energy content*	*Density*	*Life-cycle emissions intensity*[b]	*Life-cycle emissions intensity*
		MJ/L	kg/L	g CO_2-e/MJ	g CO_2-e/L petrol equivalent
Petrol	Petroleum	33.2	0.74	89.0	2 951
Diesel	Petroleum	37.7	0.87	89.0	2 951
LPG	Petroleum	25.6	0.54	77.0	2 553
Ethanol		21.2	0.79	..	..
High	Cassava	..	..	75.0	2 486
Central	Cassava	..	..	75.0	2 486
Low	Cassava	..	..	71.0	2 360
High	Maize	..	..	131.0	4 343
Central	Maize	..	..	94.0	3 116
Low	Maize	..	..	71.0	2 360
High	Wheat	..	..	108.0	3 580
Central	Wheat	..	..	108.0	3 580
Low	Wheat	..	..	71.0	2 360
Biodiesel		33.4	0.89	..	..
	Recycled cooking oil	..	..	75.0	2 486

a All energy content and density figures are from Yan and Crookes (2009) except for energy densities for biodiesel and ethanol. The energy densities of biodiesel and ethanol are assumed to be the same as the United States. **b** Central estimates of emissions intensity are from Yan and Crookes (2009), low estimates are from Yan et al. (2009) and high estimates are Productivity Commission estimates. **..** Not applicable

Sources: Yan and Crookes (2009); Yan et al. (2009); Productivity Commission estimates.

Table M.4 **Fuel properties and emissions intensities[a]**

Germany

Fuel type	*Feedstock[a]*	*Energy content[b]*	*Density*	*Life-cycle emissions intensity[c]*	*Life-cycle emissions intensity*
		MJ/L	kg/L	g CO_2-e/MJ	g CO_2-e/L petrol equivalent
Petrol	Petroleum	32.2	0.75	86.0	2 769
Diesel	Petroleum	35.9	0.83	87.5	2 818
LPG	Petroleum	25.3	0.55	73.7	2 373
Ethanol		21.1	0.79[c]	..	..
	Wheat	..	..	50.0	1 610
	Sugar beet	..	..	24.0	773
	Sugar cane (imported from Brazil)	..	..	33.0	1 063
	Organic waste	..	..	10.0	322
Biodiesel		32.7	0.89[c]	..	..
	Palm oil (imported from Malaysia)	..	..	32.0	1 030
	Rapeseed oil	..	..	46.0	1 481
	Recycled cooking oil	..	..	10.0	322
	Soybean oil(imported from the Americas)	..	..	50.0	1 610
Vegetable oil	Rapeseed oil	34.6	..	35.0	1 127

a Rapeseed oil and all ethanol feedstocks except for sugar cane and organic waste are sourced both domestically and from elsewhere in Europe. **b** Energy content and density figures for petrol, diesel and LPG are from JEC-EUCAR-CONCAWE (2008a). Energy content figures for ethanol, biodiesel and vegetable oil are from ARR (Germany) (2010). Energy density figures for ethanol and biodiesel are assumed to be the same as for the United States. **c** Emissions intensities for petrol, diesel and LPG are from JEC-EUCAR-CONCAWE (2008a; 2008b). Emissions intensities of biofuels are from FMENCNS (Germany) (2010). **..** Not applicable

Sources: ARR (Germany) (2010); FMENCNS (Germany) (2010); JEC-EUCAR-CONCAWE (2008a; 2008b).

Table M.5 **Fuel properties and emissions intensities**[a]

Japan

Fuel type	*Feedstock*	*Energy content*	*Density*	*Life-cycle emissions intensity*	*Life-cycle emissions intensity*
		MJ/L	kg/L	g CO_2-e/MJ	g CO_2-e/L petrol equivalent
Petrol	Petroleum	32.2	0.75	85.3	2 747
Diesel	Petroleum	35.5	0.83	79.8	2 570
LPG	Petroleum	25.4	0.55	72.6	2 338
Ethanol		21.2	0.79	..	..
	Rice (paddy field with water management)	..	..	91.6	2 950
	Rice (paddy field without water management)	..	..	57.3	1 845
	Sugar beet	..	..	39.3	1 265
	Sugar cane (imported from Brazil)	..	..	32.7	1 053
	Waste wood	..	..	8.2	264
	Wheat	..	..	44.2	1 423

a Biodiesel is not included because no biodiesel policies were assessed for Japan. Energy content, energy density and emissions intensity of petroleum-derived fuels are from MIRI (2004). Emissions intensities of ethanol are from METI (Japan) (2010b). The energy density of ethanol is assumed to be the same as the United States. The Commission estimated the energy content of ethanol assuming 26 800 MJ/t (IEA 2010e). **..** Not applicable

Sources: IEA (2010e); METI (Japan) (2010b); MIRI (2004); Productivity Commission estimates.

Table M.6 **Fuel properties and emissions intensities**[a]

New Zealand

Fuel type	*Feedstock*	*Energy content*	*Density*	*Life-cycle emissions intensity*[b]	*Life-cycle emissions intensity*
		MJ/L	kg/L	g CO_2-e/MJ	g CO_2-e/L petrol equivalent
Petrol	Petroleum	32.7	0.75	88.4	2 892
Diesel	Petroleum	35.9	0.84	85.5	2 798
LPG	Petroleum	24.4	0.53	76.4	2 500
Ethanol		23.5	0.79	..	..
	Whey	..	..	61.6	2 016
	Sugar cane (imported from Brazil)	..	..	20.3	664
Biodiesel		32.8	0.89	..	..
	Rapeseed oil	..	..	59.8	1 957
	Recycled cooking oil	..	..	22.5	736
	Tallow	..	..	21.8	713

a Energy and density factors for petrol and diesel are for Automotive Gas Oil and LPG 60/40 net calorific values (MED (NZ) 2010b). The energy and density figures for petrol have been converted to a weighted average of premium and regular unleaded using consumption data from MED (NZ) (2011d). Energy density figures for ethanol and biodiesel are assumed to be the same as the United States. The Commission estimated the energy content of ethanol and biodiesel assuming 26 800 MJ/t for ethanol and 36 800 MJ/t for biodiesel (IEA 2010e). **b** Emissions intensity figures for petroleum-derived fuels are derived from Barber (2009), for whey ethanol from URS (2009b), for sugar cane from Barber et al. (2008), for all biodiesel feedstocks from URS (2009b) and for petrol, diesel and LPG from MED (NZ) (2011d). **..** Not applicable

Sources: Barber (2009); Barber et al. (2008); IEA (2010e); MED (NZ) (2010b; 2011d); URS (2009a; 2009b); Productivity Commission estimates.

Table M.7 **Fuel properties and emissions intensities**[a]

South Korea

Fuel type	*Feedstock*	*Energy content*[b]	*Density*	*Life-cycle emissions intensity*[c]	*Life-cycle emissions intensity*
		MJ/L	kg/L	g CO_2-e/MJ	g CO_2-e/L petrol equivalent
Petrol	Petroleum	33.5	0.75	85.3	2 858
Diesel	Petroleum	37.9	0.83	79.8[d]	2 673
LPG	Petroleum	27.5	0.55	72.6	2 432
Biodiesel		34.0[e]	0.89[f]	..	..
High	Palm oil (imported from Indonesia or Malaysia)	..	..	75.5	2 528
Central	Palm oil (imported from Indonesia or Malaysia)	..	..	69.4	2 325
Low	Palm oil (imported from Indonesia or Malaysia)	..	..	61.7	2 068
High	Soybean oil (imported from Brazil or Argentina)	..	..	76.3	2 557
Central	Soybean oil (imported from Brazil or Argentina)	..	..	68.6	2 298
Low	Soybean oil (imported from Brazil or Argentina)	..	..	62.5	2 092
	Recycled cooking oil	..	..	11.2	375

a Fuel densities and emissions intensity estimates for petroleum-derived fuels were not available for South Korea, and hence the same values as Japan have been used. **b** Energy content values for petroleum-derived fuels are from KEEI (2010a). A value for LPG was not published and hence the values for butane and propane have been used, assuming a ratio of 60:40. **c** Central estimates for imported feedstocks were generated by the Commission using the RFA (UK) (2010a) Carbon Calculator. High and low estimates for imported feedstocks are Productivity Commission estimates assuming ten per cent above and below Carbon Calculator figures; the figure for recycled cooking oil is from Singhabhandhu et al. (2006); and the figure for diesel is from MIRI (2004). **d** Note that the low estimate for the analysis of biofuels policies assumes that the emissions intensity of diesel is approximately equal to the average diesel emissions intensity of other study countries (86.6 g CO_2-e/MJ). **e** Productivity Commission estimate assuming 38 210 MJ/t for biodiesel (IEA 2010e). **f** Assumed to be the same as the United States. **..** Not applicable

Sources: KEEI (2010a); IEA (2010e); MIRI (2004); RFA (UK) (2010a); Singhabhandhu et al. (2006); Productivity Commission estimates.

Table M.8 **Fuel properties and emissions intensities**

United Kingdom

Fuel type	*Feedstock*	*Energy content*	*Density*[a]	*Life-cycle emissions intensity*	*Life-cycle emissions intensity*
		MJ/L	kg/L	g CO_2-e/MJ	g CO_2-e/L petrol equivalent
Petrol	Petroleum	32.8	0.73	83.3	2 732
Diesel	Petroleum	35.9	0.84	88.5	2 903
LPG	Petroleum	25.4	0.55[b]	66.0	2 165
Ethanol		21.3	0.79	..	..
	Barley	..	..	106.0	3 477
	Cassava	..	..	115.0	3 772
	Maize	..	..	49.0	1 605
	Molasses	..	..	56.0	1 851
	Sugar beet	..	..	22.0	708
	Sugar cane	..	..	24.0	803
	Triticale	..	..	66.0	2 167
	Wheat	..	..	64.0	2 108
	Unknown[c]	..	..	115.0	3 772
Biodiesel		35.7	0.89	..	..
	Maize	..	..	18.0	590
	Rapeseed oil	..	..	60.0	1 956
	Palm oil	..	..	46.0	1 518
	Soybean oil	..	..	50.0	1 650
	Sunflower oil	..	..	67.0	2 207
	Tallow	..	..	16.0	511
	Recycled cooking oil	..	..	13.0	427
	Unknown[c]	..	..	93.0	3 043

a The Commission assumed the energy density figures for ethanol and biodiesel to be the same as the United States. **b** Density data are not published for LPG in DECC (UK) (2010a) and hence the values for butane and propane have been used, assuming a ratio of 60:40. **c** Where the feedstock is unknown, the RFA assumes emissions intensity equivalent to the highest intensity of any feedstock estimated. **..** Not applicable

Sources: DECC (UK) (2010a); DEFRA (UK) (2010); RFA (UK) (2010b); Productivity Commission estimates.

Table M.9 **Fuel properties and emissions intensities**

United States

Fuel type	*Feedstock*	*Energy content*[a]	*Density*	*Life-cycle emissions intensity*[b]	*Life-cycle emissions intensity*
		MJ/L	kg/L	g CO_2-e/MJ	g CO_2-e/L petrol equivalent
Petrol	Petroleum	34.0	0.75	85.3	2 904
Diesel	Petroleum	38.3	0.85	87.8	2 988
LPG	Petroleum	23.9	0.51	83.6	2 846
Ethanol		23.5	0.79	..	..
	'Cellulosic'[c]	..	..	5.1	174
	Maize	..	..	62.2	2 116
	Sugar cane	..	..	22.8	775
Biodiesel		35.7	0.89	..	..
	Soybean oil	..	..	19.7	669

a Energy content values are from EIA (US) (2010a). **b** The value for cellulosic ethanol is from ANL (US) (2010); all other values are from ANL (US) (2011). **c** 'Cellulosic' ethanol refers to ethanol produced from cellulose, hemicellulose or lignin (that is, not from plant starches or sugars). **..** Not applicable

Sources: ANL (US) (2010; 2011); EIA (US) (2010a).

Summary of life-cycle emissions estimates

Tables M.10 to M.12 provide cross-country comparisons of the emissions intensity estimates for petroleum-derived fuels, ethanol and biodiesel. While estimates of the emissions intensity of petroleum-derived fuels are relatively similar across study countries, estimates for ethanol and biodiesel vary significantly.

Estimates for the United Kingdom include ethanol feedstocks with the highest emissions intensity (such as barley imported from Spain and cassava imported from Cambodia), although these feedstocks account for only a small share of total ethanol consumption. High estimates for the emissions intensity of both ethanol and biodiesel feedstocks in China reflect high fertilisation rates during the planting of feedstocks and China's relatively high energy consumption in industrial processes (Ou et al. 2009).

Estimates for biodiesel consumed in South Korea produced from palm oil and soybean oil are also relatively high. As discussed above, these estimates are based on default estimates from the RFA's Carbon Calculator which are deliberately high.

Table M.10 **Summary of LCA estimates for petroleum-derived fuels**

Emissions intensity by fuel type (g CO_2-e/MJ)

	Australia	*China*	*Germany*	*Japan*	*New Zealand*	*South Korea*	*United Kingdom*	*United States*
Petrol	88.4	89.0	86.0	85.3	88.4	85.3	83.3	85.3
Diesel	85.5	89.0	87.5	79.8	85.5	79.8	88.5	87.8
LPG	76.4	77.0	73.7	72.6	76.4	72.6	66.0	83.6

Source: Tables M.2 to M.9.

Table M.11 **Summary of LCA estimates for ethanol**

Emissions intensity by feedstock (g CO_2-e/MJ), central estimates

	Australia	*China*	*Germany*	*Japan*	*New Zealand*	*United Kingdom*	*United States*
Cellulosic	..	..	..	..	..	..	5.1
Barley	..	..	..	..	..	106.0	..
Cassava	..	75.0	..	..	..	115.0	..
Maize	..	94.0	..	..	..	49.0	62.2
Grain	..	..	50.0	..	..	..	..
Molasses	55.7	..	..	..	..	56.0	..
Organic waste	..	..	10.0	..	..	..	..
Rice (paddy field with water management)	..	..	..	91.6	..	..	..
Rice (paddy field without water management)	..	..	..	57.3	..	..	..
Sorghum	61.9	..	..	..	..	..	..
Sugar beet	..	..	24.0	39.3	..	22.0	..
Sugar cane	..	..	33.0	32.7	20.3	24.0	22.8
Triticale	..	..	..	..	..	66.0	..
Waste wood	..	..	..	8.2	..	..	..
Wheat	..	108.0	..	44.2	..	64.0	..
Wheat starch	55.7	..	..	..	..	..	..
Whey	..	..	..	..	61.6	..	..
Unknown	..	..	..	..	..	115.0[a]	..

a In the United Kingdom, where the feedstock is unknown the emissions intensity is assumed to be equal to that of the most emissions-intensive estimate for any feedstock or importing country. **..** Not applicable

Source: Tables M.2 to M.9.

Table M.12 **Summary of LCA estimates for biodiesel**

Emissions intensity by feedstock (g CO_2-e/MJ), central estimates

	Australia	*China*	*Germany*	*New Zealand*	*South Korea*	*United Kingdom*	*United States*
Maize	..	..	..	..	..	18.0	..
Palm oil	..	..	32.0	..	69.4	46.0	..
Rapeseed oil	43.3	..	46.0	59.8	..	60.0	..
Recycled cooking oil	10.9	75.0	10.0	22.5	11.2	13.0	..
Soybean oil	32.6	..	50.0	..	68.6	50.0	19.7
Sunflower oil	..	..	..	..	..	67.0	..
Tallow	20.9	..	..	21.8	..	16.0	..
Unknown[a]	..	..	..	..	..	93.0	..

a In the United Kingdom, where the feedstock is unknown the emissions intensity is assumed to be equal to that of the most emissions-intensive estimate for any feedstock or importing country. **..** Not applicable

Source: Tables M.2 to M.9.

N Supply-side analysis for road transport

This appendix sets out the detailed calculations, assumptions and data sources used to estimate the subsidy equivalent, abatement and implicit abatement subsidy for biofuel policies in each study country.

Table N.1 shows the breakdown of policies analysed for each country. Key terminology and definitions are specified in box N.1.

Table N.1 **Biofuel policies analysed, by country**

Country	*Subsidies*	*Mandates*
Australia	Ethanol Production Grants program	..
	Cleaner Fuels Grant Scheme	
China	Biodiesel tax incentives	National Scheme of Extensive Pilot Projects on Bioethanol Gasoline for Automobiles
	Ethanol tax incentives	
	Flexible Subsidies for Loss	
Germany	Energy Tax exemption for biofuels	Biofuel Quota Act
Japan	Ethanol fuel tax exemption	..
New Zealand	Ethanol fuel tax exemption	..
	Biodiesel Grants Scheme	
South Korea	Biodiesel tax rebate	..
United Kingdom	..	Renewable Transport Fuels Obligation
United States	Alcohol Fuel Credit	Federal Fleet Management Guidance
	Biodiesel Fuel Credit	Renewable Fuel Standard
	Bioenergy Program for Advanced Biofuels	
	State excise concessions for ethanol	

.. Not applicable.

Box N.1 **Terminology and definitions**

- Biodiesel — a form of diesel fuel that is derived from plant or animal matter.
- Cellulosic ethanol — ethanol produced from cellulose, hemicellulose or lignin (that is, not from plant starches or sugars).
- Conventional fuels — the two most widely used road transport fuels, petrol and diesel.
- Diesel — a middle distillate derived from a petroleum refining process (also referred to as light fuel oil, distillate fuel oil or automotive gas oil in some countries).
- Ethanol — ethyl alcohol, most commonly derived from biomass and used as a vehicle fuel.
- Ethanol-blended fuel — a mixture of petrol and ethanol. The name used in some countries refers to the proportion of ethanol (for example, E10 is 10 per cent ethanol and 90 per cent petrol).
- Export parity price — the price that fuel producers could receive by selling fuel for export rather than selling fuel domestically.
- Import parity price — the cost of importing fuel (including transport and import costs).
- LPG — liquefied petroleum gases used as vehicle fuel.
- Petrol — automotive gasoline distilled from petroleum (this includes 'regular unleaded' and 'premium unleaded' in Australia).
- Petrol equivalent — a measure to compare fuel volumes (for example, biofuels or diesel) consistently by energy content. It is the volume of petrol that has the same energy content as one litre of a given fuel.
- Petroleum — liquid hydrocarbons as extracted from the earth (often called oil or crude oil).
- Terminal gate price — the advertised price of fuel for sale at the terminal gate of refiners or importers, which is often used as a reference to determine actual wholesale prices to customers.

N.1 Approach

All eight study countries provide some form of support to biofuels. To the extent that they are effective, biofuel policies can induce an increase in domestic biofuel consumption and displace consumption of more emissions-intensive conventional fuels (such as petrol and diesel). This abatement occurs on the supply side of the fuel market.

The biofuel analysis was conducted separately for the two main fuel markets in each country (petrol and diesel) for which there are biofuel substitutes (ethanol and biodiesel). The focus of the analysis is on the *consumption* of these fuels. Where biofuels are imported, these are incorporated in the analysis. In contrast, biofuels that are produced domestically, but exported and consumed in another country, are excluded. This captures the costs of reducing greenhouse gas emissions through biofuels that are consumed in the country only.

Policy overlaps

Where possible, the subsidy equivalent, abatement and implicit abatement subsidy were estimated for each policy measure. In some cases, the Commission was able to identify the effect that an individual policy has on the total consumption of biofuels within a country, and thus provide these estimates.

In other cases, however, it was more difficult to quantify the effects of individual policy measures on total biofuel consumption. This was often the case when policies interact (or 'overlap') by targeting the same type of biofuel — for example, when biofuel that is subsidised by a policy can be counted towards meeting a separate biofuel mandate. In these cases, a description of each policy measure is provided, followed by a 'whole-of-market' analysis. This estimates the combined impacts of policies, rather than looking at the impacts of each policy in isolation. Such an approach means that the total abatement and costs of the assistance measures as a whole can be estimated, even though it may be impossible to identify the incremental costs and abatement of individual policies.

The form of the 'whole-of-market' analysis depends on the types of policies that are being considered. For example, it may involve estimating the total value of subsidies that are provided. In other cases, it may entail examining a fuel content mandate by estimating the 'price premium' of biofuels relative to petrol or diesel. In all cases, it means that the total value of assistance that a country provides to biofuels — through a number of policy measures — is quantified (box N.2).

The approach used to examine policies in each country is set in the relevant country section, as is a discussion of any policy overlaps. For each country, estimates — across all policy measures — are provided for the total subsidy equivalent, total abatement and average implicit abatement subsidy.

Box N.2 **Policy overlaps**

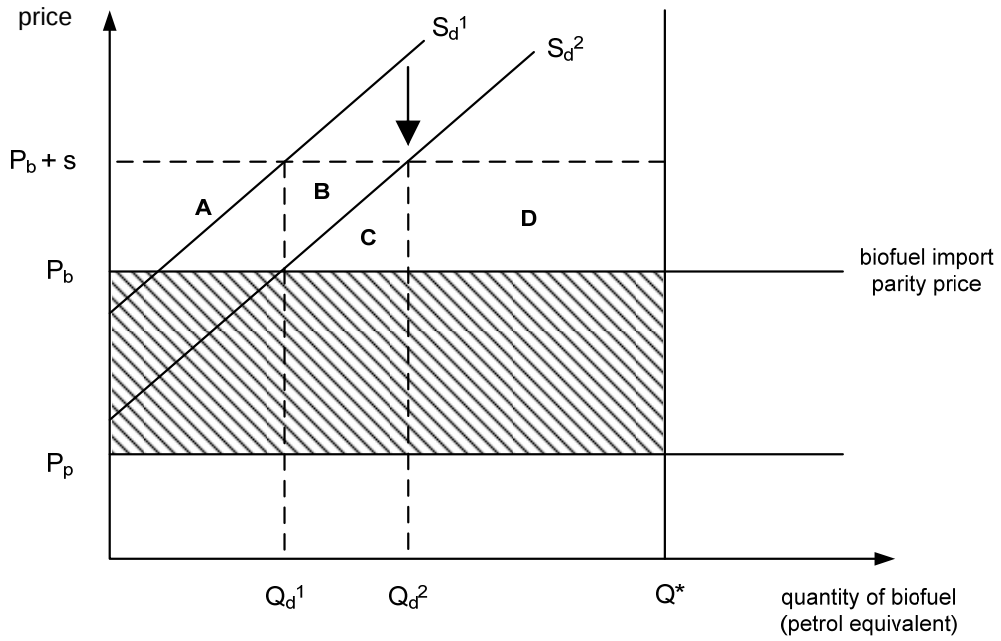
This figure depicts a market with a binding fuel content mandate that raises demand for biofuel to the mandated level (Q^*). By creating additional demand for ethanol, the mandate raises the price that biofuel producers receive (P_b) above the price of petrol (P_p). The subsidy equivalent of the mandate is shown by the shaded rectangle.

Where a production subsidy (s) is also provided (in conjunction with the binding fuel content mandate), it will increase the domestic production of biofuels at the expense of imports (shifting the domestic supply curve for biofuels down from S_d^1 to S_d^2). The total quantity of biofuel consumed is unchanged (at Q^*) due to the binding mandate.

If the subsidy is only provided to domestic producers it will increase resource costs by shifting consumption towards higher-cost domestic production (the consumption of domestically-produced biofuel increases from Q_d^1 to Q_d^2). This could also have an effect on abatement, depending on what feedstocks are used for domestic production and imports.

The additional increase in resource costs (due to the subsidy) is depicted by area C. The total subsidy equivalent of the mandate and the subsidy (in combination) is the shaded area plus A+B+C.

In contrast, where the subsidy is provided to both domestic and foreign producers, this will not change the incentive for domestic production. The increase in resource costs will depend on the extent to which foreign producers receive the subsidy. In this case, the total subsidy equivalent of the mandate and the subsidy (in combination) is the shaded area plus A+B+C+D.



Policy-induced consumption

In determining the costs and abatement associated with a given biofuel policy, it is important to take into account that some level of biofuel consumption may have taken place even if the policy was not in place. Three terms are used throughout this appendix when referring to the calculations involved in estimating subsidy equivalents:

- Total consumption — current level of total consumption of a given biofuel.
- Counterfactual consumption — the level of consumption, of a given biofuel, that would have taken place in the absence of the policy measure (or measures).
- Policy-induced consumption — the level of consumption due to the policy measure (or measures) (that is, policy-induced consumption is equal to total consumption less counterfactual consumption).

For most study countries, there was not sufficient evidence to accurately estimate counterfactual consumption. In the absence of this evidence, the Commission has adopted a default assumption that no consumption of biofuels would have taken place without government support (where evidence was available to suggest otherwise, sensitivity analysis was used). In some cases, this may mean that the estimates of subsidy equivalents and abatement are overstated because they include the impact of consumption that would have occurred in the absence of policies. However, because this assumption affects the subsidy equivalents and abatement proportionally, it has no impact on the estimated implicit abatement subsidies.

Estimating abatement

Abatement for any given policy was analysed using 'average abatement factors'. These factors reflect the difference in life-cycle emissions intensity between a biofuel and the conventional fuel displaced (measured in grams of carbon dioxide-equivalent per litre (g CO_2-e/L) (petrol equivalent)). Life-cycle emissions refer to the total greenhouse gas emissions produced during the 'life' of a fuel, beginning with emissions from feedstock generation or extraction through to emissions from combustion (appendix M).

In estimating the emissions intensity of a biofuel for a given country, the Commission took into account the different feedstocks that are used in the country (data permitting). This is because the choice of feedstock is the most significant determinant of the emissions intensity of biofuels. The total abatement attributable to a policy or policies was calculated by multiplying the average abatement factor (for a given biofuel and country) by the level of policy-induced consumption.

Currency conversion and timing

Where data permitted, subsidy equivalents, abatement and implicit abatement subsidies were estimated for the 2010 calendar year. However, due to data availability, some estimates were calculated for other time periods.

Subsidy equivalents and implicit abatement subsidies were converted to 2010 values (using GDP deflators) and then converted to Australian dollars. This was done using the deflators and exchange rates listed in table N.2.

Table N.2 **Exchange rates to 2010 Australian dollars**

Country	*Currency*	*Data year used for analysis*	*Deflator to 2010*[a]	*Exchange rate per A$*[b]
Australia	Australian dollar (A$)	July 2009 – June 2010	1.03	1
China	Chinese yuan (CNY)	January – December 2009	1.06	6.2167
Germany	euro (€)	January – December 2009	1.01	0.6979
Japan	Japanese yen (¥)	April 2009 – March 2010	0.98	80.12
New Zealand	New Zealand dollar (NZ$)	January – December 2010	1.00	1.2778
South Korea	Korean won (KRW)	January – December 2010	1.00	1065.08
United Kingdom	pound sterling (£)	April 2009 – March 2010	1.03	0.5963
United States	US dollar (US$)	January – December 2009	1.01	0.9199

a Deflators to 2010 values (in local currency) are based on the GDP chain price index from the RBA (2011) for Australia, and from the IMF (2011) for all other countries (using the whole calendar year that covers most of the data analysis period). **b** Annual average exchange rates for 2010 are from the RBA (2011).

Sources: IMF (2011); RBA (2011).

Adjusting fuel volumes for energy content

The fuel types discussed in this appendix (petrol, diesel, ethanol, biodiesel and vegetable oil) each have different energy contents (measured as megajoules per litre (MJ/L) upon combustion). Where convenient and appropriate, fuel volumes used in calculations are presented in terms of 'litres of petrol equivalent'. This takes into account the energy content of each fuel relative to petrol and provides a consistent metric to present volumes of fuel. This conversion is applied to all fuels, including diesel and biodiesel (appendix M).

Sensitivity analysis

For some of the policies that were analysed in detail, the Commission carried out sensitivity analysis. This was generally done when there were differences across available sets of data. The results of the sensitivity analysis are reported in comparison to the Commission's 'central' estimate. The 'central' estimate is based

on the set of assumptions that the Commission considers to be most consistent with its approach to estimating subsidy equivalents and abatement.

A key variable for sensitivity analysis is life-cycle emissions intensity. The Commission's approach has been to rely on government estimates of life-cycle emissions intensity by feedstock where available. Where these were not available, sources conflict or estimates are uncertain, sensitivity analysis was undertaken.

N.2 Australia

The Commission estimated the subsidy equivalent, abatement and implicit abatement subsidy for two biofuel policies in Australia: the Ethanol Production Grants (EPG) program, and the Cleaner Fuels Grants Scheme (CFGS). The default assumption for the counterfactual — that is, no domestic consumption or production of ethanol or biodiesel was expected to take place in the absence of government support — was applied in this analysis.

Both policies were analysed for the 2009-10 financial year (July 2009 to June 2010). However, it is worth noting that these policies are due to change in December 2011. In the 2010-11 Budget, the Commonwealth Government announced plans to introduce energy content based taxation and reduce subsidies to biofuels. The subsidy to ethanol producers provided under the EPG program will be gradually phased out and the rate of fuel excise payable modified so that the effective tax rate on ethanol (that is, the excise net of subsidies) will be gradually increased. Similar changes are proposed for biodiesel taxation — the CFGS is to be abolished in December 2011 and the fuel excise rate on biodiesel changed so that taxation can be gradually introduced (Treasury 2011).

Abatement

Taking into account the different ethanol feedstocks used, the average abatement factor for ethanol was estimated to be 1081 g CO_2-e/L (petrol equivalent) (table N.3).

Table N.3 **Average abatement factor, ethanol**
Australia

Fuel type	*Feedstock*	*Estimated production share*[a]	*Life-cycle emissions intensity*
		%	g CO_2-e/L petrol equivalent
Ethanol	Wheat starch	68	1 904
	Sorghum	18	2 115
	Molasses	14	1 904
	Weighted average	100	1 942
Petrol	Petroleum	100	3 023
Average abatement factor	**..**	**..**	**1 081**

[a] Feedstock production shares were estimated using the production capacity of active plants from the BAA (2010b). **..** Not applicable.

Sources: BAA (2010b); Appendix M.

Taking into account the different biodiesel feedstocks used, the average abatement factor for biodiesel was estimated to be 2208 g CO_2-e/L (petrol equivalent) (table N.4).

Table N.4 **Average abatement factor, biodiesel**
Australia

Fuel type	*Feedstock*	*Estimated production share*[a]	*Life-cycle emissions intensity*
		%	g CO_2-e/L petrol equivalent
Biodiesel	Tallow	47	715
	Recycled cooking oil	37	373
	Rapeseed oil	17	1 481
	Weighted average	100	716
Diesel	Petroleum	100	2 924
Average abatement factor	**..**	**..**	**2 208**

[a] Feedstock production shares were estimated using the production capacity of active plants from the BAA (2010a). **..** Not applicable.

Sources: BAA (2010a); Appendix M.

Policy overlaps

There are no policy overlaps between Australian biofuel policies as only one policy was analysed for each fuel type. Under the default assumption, all ethanol consumption is attributable to the EPG program and all biodiesel consumption is attributable to the CFGS.

Ethanol Production Grants program

The EPG program was introduced in September 2002. Eligible producers of ethanol are paid A$0.38143 for each litre produced. For producers to be eligible, the ethanol must have been domestically produced entirely from biomass feedstocks and must be used as a transport fuel (AusIndustry 2008). This payment wholly offsets the excise on ethanol — in other words, the effective excise rate is reduced to zero.

Estimating the subsidy equivalent

The inputs used to estimate the subsidy equivalent are provided in table N.5 below. As there were no imports or exports of ethanol used for transport fuel during 2009-10, consumption is assumed to be equal to domestic production. The subsidy equivalent was estimated to be A$108 million.

Table N.5 **Subsidy equivalent, EPG program**
Australia, July 2009 – June 2010

	Units	*Value*
Subsidy rate	A$/L	0.38143
Total consumption	ML	275
Government expenditure	**A$m (2009-10)**	**105**
Counterfactual consumption	ML	0
Policy-induced consumption	ML	275
Subsidy equivalent	**A$m (2009-10)**	**105**
	A$m (2010)	**108**

Sources: AusIndustry (2008); Department of Resources, Energy and Tourism (pers. comm., 16 February 2011); Productivity Commission estimates.

Estimating abatement

Total abatement due to the EPG program was estimated to be 0.2 Mt CO_2-e (table N.6).

Table N.6 **Abatement, EPG program**
Australia, July 2009 – June 2010

	Units	*Value*
Policy-induced consumption	ML	275
	ML petrol equivalent	188
Average abatement factor	g CO_2-e/L petrol equivalent	1 081
Abatement	**Mt CO_2-e**	**0.2**

Source: Productivity Commission estimates.

The implicit abatement subsidy

The implicit abatement subsidy for the EPG program was estimated to be A$532/t CO_2-e (table N.7).

Table N.7 **Implicit abatement subsidy, EPG program**
Australia, July 2009 – June 2010

	Units	*Value*
Subsidy equivalent	A$m (2009-10)	105
	A$m (2010)	108
Abatement	Mt CO_2-e	0.2
Implicit abatement subsidy	**A$/t CO_2-e (2009-10)**	**516**
	A$/t CO_2-e (2010)	**532**

Source: Productivity Commission estimates.

Cleaner Fuels Grants Scheme

The CFGS was introduced in September 2003. As with the EPG program, eligible producers of biodiesel are paid A$0.38143 for each litre produced, wholly offsetting excise on biodiesel (ATO 2010).

Estimating the subsidy equivalent

The inputs used to estimate the subsidy equivalent are set out in table N.8 below. The subsidy equivalent was estimated to be A$35 million.

Table N.8 **Subsidy equivalent, CFGS**
Australia, July 2009 – June 2010

	Units	*Value*
Subsidy rate	A$/L	0.38143
Total consumption	ML	90
Government expenditure	**A$m (2009-10)**	**34**
Counterfactual consumption	ML	0
Policy-induced consumption	ML	34
Subsidy equivalent	**A$m (2009-10)**	**34**
	A$m (2010)	**35**

Sources: ATO (2010, 2011b); Productivity Commission estimates.

Estimating abatement

Total abatement due to the CFGS was estimated to be 0.2 Mt CO_2-e (table N.9).

Table N.9 **Abatement, CFGS**
Australia, July 2009 – June 2010

	Units	*Value*
Policy-induced consumption	ML	90
	ML petrol equivalent	86
Average abatement factor	g CO_2-e/L petrol equivalent	2 208
Abatement	**Mt CO_2-e**	**0.2**

Source: Productivity Commission estimates.

The implicit abatement subsidy

The implicit abatement subsidy for the CFGS is A$186/t CO_2-e (table N.10).

Table N.10 **Implicit abatement subsidy, CFGS**
Australia, July 2009 – June 2010

	Units	*Value*
Subsidy equivalent	A$m (2009-10)	34
	A$m (2010)	35
Abatement	Mt CO_2-e	0.2
Implicit abatement subsidy	**A$/t CO_2-e (2009-10)**	**180**
	A$/t CO_2-e (2010)	**186**

Source: Productivity Commission estimates.

Summary

The average implicit abatement subsidy

Combining the impacts of the EPG program and the CFGS, the total subsidy equivalent was estimated to be A$144 million. Total abatement was estimated to be 0.4 Mt CO_2-e and the average implicit abatement subsidy at A$364/t CO_2-e (table N.11).

Table N.11 **Average implicit abatement subsidy**
Australia, July 2009 – June 2010

	Units	*Ethanol*	*Biodiesel*	*Total*
Total subsidy equivalent	A$m (2010)	108	35	144
Total abatement	Mt CO_2-e	0.2	0.2	0.4
Average implicit abatement subsidy	A$/t CO_2-e (2010)	532	186	364

Source: Productivity Commission estimates.

N.3 China

The Commission estimated the subsidy equivalent, abatement and implicit abatement subsidy for four biofuel policies in China. Three of these apply to ethanol producers: tax exemptions, Flexible Subsidies for Loss, and the 'National Scheme of Extensive Pilot Projects on Bioethanol Gasoline for Automobiles' (NSEP). The fourth policy is tax exemptions for biodiesel producers. All policies were analysed for the 2009 calendar year.

This analysis has adopted the default assumption that there would be no domestic production or consumption of biofuels in China without government assistance. This is likely given the high costs of producing ethanol in China and the low and variable volumes of biodiesel that are produced. Further, biofuel is not imported for use as a transport fuel, and the market for fuel is tightly regulated by the Chinese Government (FAS (US) 2010a).

Abatement

Taking into account the different ethanol feedstocks used in China, the average abatement factor for ethanol was estimated to be -224 g CO_2-e/L (petrol equivalent) (table N.12). That is, on average, ethanol produced in China has a higher life-cycle emissions intensity than petrol. This means that any policy that increases the share of ethanol in total fuel consumption relative to petrol would increase greenhouse gas emissions by an average of 224 g CO_2-e/L. This result is due to the fact that maize and wheat ethanol are estimated to have higher emissions intensities than petrol on a life-cycle basis. Ethanol produced using cassava does have lower life-cycle emissions than petrol, but it represents a small proportion of total ethanol produced in China, and consequently does not have a material effect on the average abatement factor. This analysis is based on a thorough review of the literature on life-cycle emissions of ethanol in China (appendix M). However, the extent of abatement is highly sensitive to the method used to estimate life-cycle emissions and assumptions regarding the inclusion of land-use change or the treatment of

recycled or waste feedstocks. In order to reflect the range of uncertainties involved in this abatement result, sensitivity analysis was conducted.

Biodiesel is produced using recycled oil and has a lower emissions intensity than conventional diesel. The abatement factor for biodiesel is 464 g CO_2-e/L (petrol equivalent) (table N.13).

Table N.12 **Average abatement factor, ethanol**
China

Fuel type	*Feedstock*	*Estimated production share*[a]	*Life-cycle emissions intensity*
		%	g CO_2-e/L petrol equivalent
Ethanol	Maize	65	3 116
	Wheat	26	3 580
	Cassava	10	2 486
	Weighted average	100	3 175
Petrol	Petroleum	100	2 950
Average abatement factor	**..**	**..**	**-224**

a Feedstock production shares are estimated using production figures from FAS (US) (2010a) and by assuming that each plant uses only one type of feedstock. **..** Not applicable

Sources: FAS (US) (2010a); Yan and Crookes (2009); Appendix M.

Table N.13 **Average abatement factor, biodiesel**
China

Fuel type[a]	*Feedstock*	*Estimated production share*	*Life-cycle emissions intensity*
		%	g CO_2-e/L petrol equivalent
Biodiesel	Recycled oil	100	2 486
Diesel	Petroleum	100	2 951
Average abatement factor	**..**	**..**	**464**

a The estimate for biodiesel is sourced from Ou et al. (2009) and the diesel estimate is sourced from Yan and Crookes (2009). **..** Not applicable

Sources: Ou et al. (2009); Yan and Crookes (2009); Appendix M.

Policy overlap

There is significant overlap between the three policies that support ethanol production in China. Two of these policies — the tax incentives and the Flexible Subsidies for Loss — are explicit subsidies to producers, whereas the NSEP

requires that all petrol sold in six provinces and 27 cities is blended with ethanol such that ethanol comprises ten per cent of the mixture by volume.

The overlap between these policies arises, in part, because of the way the fuel market is regulated in China. Ethanol (in the form of E10) is only sold in certain provinces and cities, where the Government has fixed the price that ethanol producers receive for their output as a fixed percentage of the petrol price. As the Government has significant regulatory control over the distribution for fuel, other (unauthorised) domestic producers or importers cannot sell ethanol as a transport fuel (FAS (US) 2010a).

These regulations affect the way that the NSEP is implemented in China. Unlike other study countries, it is not clear whether this policy sets a minimum level of ethanol consumption (in the areas where it is implemented). For example, all ethanol that authorised plants produce can be sold at the regulated price, even if production falls short of (or exceeds) the amount that is specified by the NSEP. It is unclear whether ethanol producers (which are majority state-owned[1]) face penalties when NSEP requirements are not met.

While the NSEP may not strictly act as a fuel content mandate, it does provide a guaranteed market for ethanol with a set price above that for petrol, once energy content is taken into account. The difference between the wholesale price that ethanol producers receive and the wholesale petrol price is effectively a production subsidy to ethanol producers.

The Flexible Subsidies for Loss involves payments to ethanol producers to cover losses from ethanol production. It is not clear whether this scheme, along with the tax incentives, leads to additional consumption of ethanol over and above that which would occur if only the NSEP was in place. If producers are making losses, this would suggest that ethanol would not be produced with the NSEP and price controls alone, or without any other form of government intervention (and hence there would be no consumption of ethanol and no abatement).

In order to disentangle the effects of these policies — and determine the extent to which each affects the level of ethanol consumption in China — considerable data would be required on the level of subsidy provided to each ethanol plant, production costs, and volumes of production and consumption. The Commission was not able to obtain such data.

1 Four of the five ethanol plants are part or wholly-owned by China National Cereals, Oils and Foodstuffs Corporation (COFCO), a large Chinese state-owned enterprise (CNCIC 2010).

Moreover, it was unclear what amount of ethanol would be consumed in China under a different combination of these policies — for example, with tax incentives only, or with the NSEP only. It is possible that all three policies are required to induce the level of production (and hence consumption) that is actually observed.

The Commission has therefore estimated abatement and the implicit abatement subsidy for these ethanol policies jointly. It has been assumed that all three policies contribute to ethanol consumption in China. The subsidy equivalent for ethanol policies was calculated by adding up the subsidy equivalent for each policy.

As the tax incentives are the only form of government assistance provided to biodiesel producers there are no issues of policy interaction for biodiesel.

Ethanol and biodiesel production volumes

A key challenge in analysing biofuel policies in China was to source reliable and up-to-date data on the consumption of biofuels. These data were essential to estimate subsidy equivalents and implicit abatement subsidies. Tax revenue data and biofuel consumption figures were not available for China (unlike other countries). Consequently the Commission used production data as a proxy for the volume of biofuel consumed.

Ethanol production

In China, the production and distribution of ethanol is under strict government control. All fuel ethanol must be produced by government-authorised plants, and petrol blended with ethanol is distributed by government-owned petroleum companies — China Petroleum and Chemical Corporation (known as Sinopec) and the China National Petroleum Corporation (Dong 2007).

The Commission identified five authorised ethanol producers in China (table N.14). Four of these plants use grain-based feedstock and are situated in maize and wheat producing areas of eastern China (Dong 2007). In 2007, a fifth plant commenced production in Guangxi province using cassava as a feedstock (FAS (US) 2009).

The Commission has used production data from 2009 for its analysis of Chinese ethanol policies. While actual production of ethanol in China varies by year, production capacity has effectively been fixed since 2006 (for the four grain-based plants).[2] The Commission has used estimates from FAS (US) (2010a) — as no

[2] In 2006, in response to concerns regarding food security and food price inflation, the Government announced that all new ethanol plants must be approved by the National

official estimates were available — which report total ethanol production to be 1.7 Mt in 2009. This total estimate is in line with Energy Research Institute (ERI) aggregate ethanol production data (ERI, pers. comm., 20 April 2011).

Table N.14 **Ethanol producers**
China, 2009

Company	*Location*	*Feedstock*
China Resources Alcohol Co.	Heilongjiang	Maize/rice[a]
Jilin Fuel Ethanol Co.	Jilin	Maize
Henan Tian Guan Fuel-Ethanol Co.	Henan	Wheat
Anhui BBCA Biochemical Co.	Anhui	Maize/potato[b]
Guangxi COFCO Bio-Energy Co.	Guangxi	Cassava

[a] ERI (2008) and Dong (2007) cite maize as the only feedstock used at the Heilongjiang plant. However, FAS (US) (2009) states that rice is also used. [b] FAS (US) (2009) and Dong (2007) list maize as the only feedstock used at the Anhui plant. However, ERI (2008) also lists sweet potato.

Sources: Dong (2007); ERI (2008); FAS (US) (2009).

Biodiesel production

It is difficult to obtain accurate production figures for biodiesel. There is no Government agency that oversees biodiesel production or consumption (FAS (US) 2010a) and biodiesel plants tend to be smaller, more numerous and more geographically dispersed than ethanol plants (O'Kray and Wu 2010). Further, shortages in feedstock availability in recent years mean that utilisation rates are well below capacity (FAS (US) 2009). The best available estimates suggest that China's biodiesel production capacity was around 3 Mt in 2009. However, actual production has been estimated to be 0.3 Mt in that year (FAS (US) 2010a).

Production and consumption

The Commission's analysis focused on the consumption of road transport fuels (chapter 5). As discussed above, in the case of China, consumption data for road transport fuel were not available and production data were used instead. In a context where there are no imports of biofuel for road transport use and fuel ethanol production runs in tandem with planned consumption in each province or city, it is considered that production data (to the extent that it is accurate) will closely reflect actual consumption of biofuels in road transport in China. Further, it was assumed

Development and Reform Commission and prohibited the four existing ethanol plants from expanding capacity without National Development and Reform Commission approval (FAS 2009; GSI 2008b). Consequently, expansion of current production capacity is unlikely to be approved unless non-grain feedstock is utilised.

that given the planned nature of the distribution of production of the five ethanol plants, that all production of a given plant was consumed in its allotted territory.

Biodiesel tax incentives

The Chinese Government exempts biodiesel from fuel excise. Currently, the fuel excise on diesel is CNY 0.8/L. This exemption was provided to biodiesel in December 2010 (but applied retrospectively from 1 January 2009) and only applies to biodiesel that is produced using 70 per cent (or more) tallow or vegetable oil.

The Chinese Government also provides a value added tax (VAT) rebate for authorised ethanol producers and biodiesel producers, with the same eligibility criteria for biodiesel as the fuel excise exemption (FAS (US) 2009). VAT is levied at 17 per cent in China, although the FAS (US) (2010a) notes that interpretation of the tax refund varies by local area.

Estimating the subsidy equivalent

The Commission was unable to obtain estimates of forgone tax revenue from the exemptions for fuel excise and the VAT for 2009. Instead, the total subsidy provided to ethanol producers through the excise exemption was estimated by multiplying the diesel tax rate (CNY 0.8/L) by the volume of biodiesel produced in 2008. This approach assumes that all biodiesel produced in 2009 met the eligibility requirements and received the tax exemption.

An average VAT rebate per litre of biodiesel was used to estimate government revenue forgone due to the VAT rebate. The average VAT rebate per litre was calculated using an estimate of the average retail diesel price in China in 2009.[3] The price of diesel was used as the Commission was unable to obtain biodiesel prices. It is the Commission's understanding that the price of diesel acts as a ceiling for biodiesel prices (ERI, pers. comm., 11 May 2011). However, where the biodiesel price differs significantly from the price of diesel this may reduce the accuracy of the estimates.

The estimated weighted average price for diesel in 2009 was CNY 6556/t (CNY 5.2/L) (data and a brief explanation of this estimate are provided in an Annex to this appendix). Using this estimate the average rebate was calculated at CNY 0.8/L.

3 The formula used was VAT%/(1+VAT%) multiplied by the average price of diesel in 2009.

The average rebate was multiplied by the total volume of biodiesel production in 2009 to estimate revenue forgone from the VAT exemption, assuming that all biodiesel produced in 2009 was exempt from the VAT. As it was assumed that there would be no production of biodiesel without these tax exemptions, it is expected that all biodiesel produced in 2009 was induced by these policies. The subsidy equivalent was thus calculated over all production of biodiesel in 2009 and was equal to A$94 million (table N.15).

Table N.15 **Subsidy equivalent, biodiesel tax incentives**
China, 2009

	Units	*Value*
Production subsidy equivalent	CNY/L	1.6[a]
Total production	ML	337
Government revenue forgone	**CNY m (2009)**	**549**
Counterfactual consumption	ML	0
Policy-induced consumption	ML	337
Subsidy equivalent	**CNY m (2009)**	**549**
	A$m (2010)	**94**

[a] The production subsidy equivalent is equal to the excise rate exemption plus the average VAT rebate.

Sources: FAS (US) (2010a); Productivity Commission estimates.

Estimating abatement

Abatement from the biodiesel tax incentives was estimated to be 0.2 Mt CO_2-e (table N.16).

Table N.16 **Abatement, biodiesel tax incentives**
China, 2009

	Units	*Value*
Policy-induced consumption	ML	337
	ML petrol equivalent	340
Average abatement factor	g CO_2-e/L petrol equivalent	464
Abatement	**Mt CO_2-e**	**0.2**

Source: Productivity Commission estimates.

The implicit abatement subsidy

The implicit abatement subsidy was estimated to be A$592/t CO_2-e for biodiesel (table N.17).

Table N.17 **Implicit abatement subsidy, biodiesel tax incentives**
China, 2009

	Units	*Value*
Subsidy equivalent	CNY m (2009)	550
	A$m (2010)	94
Abatement	Mt CO_2-e	0.2
Implicit abatement subsidy	**CNY/t CO_2-e**	**3 479**
	A$/t CO_2-e	**592**

Source: Productivity Commission estimates.

Ethanol tax incentives

The Government exempts authorised ethanol producers from fuel excise and provides a rebate of the VAT. The excise rate on petrol is CNY 1/L and the VAT is levied at 17 per cent.

Estimating the subsidy equivalent

As noted above, the Commission was unable to obtain estimates of forgone revenues from the fuel excise exemption and VAT rebate in 2009. Instead, forgone revenue from the excise exemption was estimated by multiplying the petrol tax rate (CNY 1/L) by the volume of ethanol production in 2009.

The Commission estimated an average VAT rebate per litre of ethanol using estimates of average retail petrol prices in the provinces in which ethanol is sold (as petrol blended with ethanol is sold at the same price as conventional petrol) (Annex). The average rebate was CNY 0.7/L and was multiplied by the total volume of ethanol production in each province in 2009 to estimate of revenue forgone.

As noted previously, there is a range of policies in place in China that provide support to ethanol producers. It is unclear to what extent the tax exemptions, on their own, contributed to ethanol production (and consumption), or how much ethanol would be produced in the absence of the tax exemptions. As a result, the Commission assumed that no ethanol would be produced without these tax exemptions, with the current level of production being induced by the effect of all ethanol policies. In other words, it was assumed that policy-induced consumption equals the total volume of ethanol produced in 2009.

The subsidy equivalent for the ethanol tax incentives was estimated to be A$650 million (table N.18).

Table N.18 **Subsidy equivalent, ethanol tax incentives**
China, 2009

	Units	*Value*
Production subsidy equivalent[a]	CNY/L	1.7[a]
Total production	ML	2 178
Government revenue forgone	**CNY m (2009)**	**3 820**
Counterfactual consumption	ML	0
Policy-induced consumption	ML	2 178
Subsidy equivalent	**CNY m (2009)**	**3 820**
	A$m (2010)	**650**

[a] The production subsidy equivalent is equal to the excise rate exemption plus the average VAT rebate.

Sources: FAS (US) (2010a); Productivity Commission estimates.

Flexible Subsidies for Loss

Flexible Subsidies for Loss have been provided to ethanol producers since 2002. Initially, these subsidies were based on losses recorded from producing ethanol — the subsidy equalled the difference between revenues and production costs, plus a margin. Since 2007 the subsidy has been based on an evaluation of each individual producer's performance. The subsidy is intended to provide the producer with a minimum margin.

Estimating the subsidy equivalent

The subsidy paid to producers in 2009 varied by producer depending on financial performance. As information regarding government expenditure on this subsidy in 2009 was not available, the subsidy equivalent was calculated using an average subsidy value. The average subsidy paid in 2009 was CNY 2185/t of production (equivalent to CNY 1.7/L) (ERI, pers. comm., 20 April 2011).

Given the nature of the subsidies, it was assumed that in their absence there would be no consumption of ethanol — that is, producers would not earn sufficient profit and would not produce. This requires subsidies to be closely associated with a producer's actual profit and for these producers to operate efficiently. The Commission was unable to obtain detailed information on these subsidies in order to confirm this. Consequently, it was assumed that the Flexible Subsidies for Loss contribute to inducing all ethanol production in China (and hence consumption) — that is, policy-induced consumption equals the total volume of ethanol produced in 2009.

The subsidy equivalent for the Flexible Subsidies for Loss was estimated to be A$640 million (table N.19).

Table N.19 **Subsidy equivalent, Flexible Subsidies for Loss**
China, 2009

	Units	*Value*
Average subsidy rate	CNY/L	1.7
Total production	ML	2 178
Government expenditure	**CNY m (2009)**	**3 758**
Counterfactual consumption	ML	0
Policy-induced consumption	ML	2 178
Subsidy equivalent	**CNY m (2009)**	**3 758**
	A$m (2010)	**640**

Sources: FAS (US) (2010a); Productivity Commission estimates.

National Scheme of Extensive Pilot Projects on Bioethanol Gasoline for Automobiles (NSEP)

The NSEP commenced in February 2004 and mandated a 10 per cent blend of ethanol in petrol in six provinces (Heilongjiang, Jilin, Liaoing, Henan, Guangxi and Anhui), nine cities in Hubei province, seven cities in Shandong province, six cities in Hebei and five cities in Jiangsu (Dong 2007).[4] Several sources have reported the distribution of ethanol by province under the NSEP (table N.20). Under the scheme, the purchase or sale of petrol that is not blended with 10 per cent ethanol is prohibited in the cities and provinces covered by the scheme (Dong 2007). However, an exemption is provided for the army and state reserves.

Due to a lack of detailed production and consumption data at the national, provincial and metropolitan levels, the Commission was unable to determine to what extent this mandate binds. However, the Commission understands that achievement of full replacement of petrol with 10 per cent ethanol in the target cities and provinces is also contingent on the production capacity of the four plants (ERI, pers. comm., 28 April 2011). Consequently, the NSEP appears to set a 'mandate' at the current level of ethanol production. In other words, the Government effectively provides a guaranteed market for ethanol producers without setting a strict floor on production.

4 This policy extends the 'State Scheme of Pilot Projects on Bioethanol Gasoline for Automobiles' which had been in place since June 2001 (Dong 2007).

Through its regulation of fuel prices, the Government also effectively subsidises producers by regulating the price of ethanol relative to petrol. The wholesale price of ethanol paid is set at 91 per cent of the wholesale price of petrol ('grade 90 gasoline', that is, petrol with an octane rating of 90) (GSI 2008b). Taking into account differences in energy content between ethanol and petrol, this means that ethanol producers receive a 40 per cent price premium above the petrol price.

Table N.20 **Distribution of ethanol production by province under the NSEP**

China, 2004

Producer	*Location of plant*	*Distribution of production*
		tonnes
China Resources Alcohol Co.	Heilongjiang	100 000 (Heilongjiang)
Jilin Fuel Ethanol Co.	Jilin	100 000 (Jilin province) 200 000 (Liaoning province)
Henan Tianguan Fuel Ethanol Co.	Henan	130 000 (Henan) 170 000 (Hubei and Hebei)
Anhui BBCA Biochemical Co.	Anhui	100 000 (Anhui) 220 000 (Shandong, Jiangsu and Hebei)
COFCO Bio-energy Co.	Guangxi	na
Total		**1 020 000**

na Not available.

Sources: CNCIC (2010); Dong (2007).

Estimating the subsidy equivalent

In order to estimate a subsidy equivalent for the NSEP and government price controls, wholesale ethanol and petrol price data for 2009 were required.

The Chinese Government regulates petrol prices such that domestic prices adjust in line with international markets (with a lag to minimise price fluctuations). The National Development and Reform Commission (NDRC) issues a notice each time that regulated prices are changed. These notices stipulate maximum 'standard' retail and wholesale prices for petrol and diesel by province. The retail price of petrol or ethanol cannot exceed the standard price, but can be less than this price (ERI pers. comm., 28 April 2011; Dong 2007).

The wholesale price of petrol is increased or reduced with the release of the price notices. The Chinese Government regulates that the wholesale price of petrol and diesel must be no higher than the retail price minus CNY 300/t (where the supplier

incurs transport cost) (NDRC (China) 2011).[5] Therefore, a retail price of petrol of CNY 6000/t would mean that the wholesale price for petrol could be up to CNY 5700/t and for ethanol CNY 5192/t (which was equal to CNY 8094/t (petrol equivalent) when adjusted for energy content).

Throughout its analysis the Commission used the standard prices issued by the NDRC. However, these standard prices reflect the maximum retail and wholesale price that can be charged. Consequently, estimated average retail and wholesale prices could overstate the actual prices during 2009.

These price data were used to estimate the production subsidy equivalent of the NSEP the price premium that ethanol producers receive above the wholesale petrol price (that is, the wholesale ethanol price minus the wholesale petrol price) To estimate this premium, the Commission estimated average wholesale ethanol and petrol prices for the ten provinces where the NSEP was in place in 2009.

Over 2009, the NDRC released eight notices to revise regulated oil prices. An average of retail petrol prices (for 'grade 90 gasoline') has been estimated for each province, weighted by the time period over which these standard prices were in place (Annex). An average wholesale price of petrol for each province was then estimated to be CNY 300/t less than the average retail price.

Using the average wholesale petrol price estimate, an average wholesale ethanol price was derived for each province (at 91 per cent of the wholesale petrol price). This price was then adjusted for energy content to calculate the price premium that ethanol receives.

On average, this price premium equates to a production subsidy equivalent of CNY 2778/t (A$473/t). The subsidy equivalent was estimated by multiplying the production subsidy equivalent for each province by an estimate of annual consumption by province (table N.22). The estimate of annual production is based on the distribution of production set out in table N.20.

It was not possible to determine the incremental impacts that the NSEP had on ethanol production. The Commission considers that the NSEP did increase ethanol production (and hence consumption) in China but could not determine to what extent. It was assumed that the NSEP contributes to inducing all ethanol production in China — that is, policy-induced consumption equals the total volume of ethanol produced in 2009.

5 Where the contract does not include delivery, the relevant pricing departments in the province or region must adjust the standard wholesale price (retail price minus CNY 300/t) taking into account transport costs (NDRC (China) 2011).

‘Whole-of-market’ analysis

A whole-of-market approach was used to estimate the total subsidy equivalent, total abatement and average implicit abatement subsidy for ethanol and biodiesel in China.

Estimating the total subsidy equivalent

In order to estimate a total subsidy equivalent for all ethanol policies combined, the subsidy equivalents for each policy were added together. This approach is likely to overestimate true resource costs and thus represents an upper bound. The subsidy equivalent for all ethanol support policies in China was estimated to be A$1.9 billion (table N.21). The total subsidy equivalent for all biofuel policies in China was estimated to be A$2.0 billion.

Table N.21 **Total subsidy equivalent**
China, 2009

	Units	*Ethanol*	*Biodiesel*	*Total*
Tax incentives	CNY m (2009)	3 820	549	4 369
	A$m (2010)	650	94	744
Flexible subsidies for loss	CNY m (2009)	3 758	..	3 758
	A$m (2010)	640	..	640
NSEP	CNY m (2009)	3 606	..	3 606
	A$m (2010)	614	..	614
Total subsidy equivalent	**CNY m (2009)**	**11 184**	**549**	**11 733**
	A$m (2010)	**1 904**	**94**	**1 998**

.. Not applicable.

Source: Productivity Commission estimates.

Table N.22 **Subsidy equivalent, NSEP[a]**

China, 2009

	Units	*China Resources Alcohol Co.*	*Jilin Fuel Ethanol Co.*		*Henan Tian Guan Fuel Ethanol Co.*		*Anhui BBCA Biochemical Co.*		*Guangxi COFCO*
Province		Heilongjiang	Jilin	Liaoning	Henan	Hubei & Hebei[b]	Anhui	Shandong, Jiangsu & Hebei[b]	Guangxi
Average ethanol wholesale price	CNY/litre	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.9
	CNY/litre petrol equivalent	7.5	7.5	7.5	7.6	7.6	7.6	7.6	7.7
Average wholesale petrol price	CNY/litre petrol equivalent	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.1
Production subsidy equivalent	**CNY/litre petrol equivalent**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**
Total production	ML petrol equivalent	154	270	135	274	84	154	185	135
Counterfactual consumption	ML petrol equivalent	0	0	0	0	0	0	0	0
Policy-induced consumption	ML petrol equivalent	154	270	135	274	84	154	185	135
Subsidy equivalent	**CNY m (2009)**	**397**	**696**	**348**	**710**	**218**	**400**	**479**	**356**
	A$m (2010)	**68**	**118**	**59**	**121**	**37**	**68**	**82**	**61**

a As the Commission does not have data on the distribution of production in 2009, it was assumed that all ethanol produced in 2009 was included under the NSEP and received a fixed wholesale price and a guaranteed market. Where one plant provided ethanol to multiple provinces the original proportions of distribution between provinces (ERI 2008) was applied to the 2009 levels of production. **b** As data on the distribution of production between Hubei and Hebei from Henan Tian Guan Fuel Ethanol Co. or Shandong, Jiangsu and Hebei from Anhui BBCA Biochemical Co. were not available, it was not possible to estimate a subsidy equivalent for each province. Instead, the Commission assumed that production was apportioned equally between provinces and a simple average price was used to estimate the subsidy equivalent.

Sources: Tan et al. (2010); NDRC (China) (2011); Productivity Commission estimates.

Total abatement

As it was assumed that there would be no ethanol or biodiesel production in China without government support, the total increase in consumption due to the policies was equal to current consumption. Total abatement was estimated to be -0.3 Mt CO_2-e for ethanol and 0.2 Mt CO_2-e for biodiesel (table N.23).

Table N.23 **Total abatement[a]**
China, 2009

	Units	*Ethanol*	*Biodiesel*
Policy-induced consumption	ML	2 178	337
	ML petrol equivalent	1 391	340
Average abatement factor	g CO_2-e/L petrol equivalent	-224	464
Abatement	**Mt CO_2-e**	**-0.3**	**0.2**

a Abatement was not aggregated for ethanol and biodiesel due to the negative abatement result for ethanol.

Source: Productivity Commission estimates.

The average implicit abatement subsidy

The average implicit abatement subsidy was estimated to be -A$6105/t CO_2-e for ethanol and A$592/t CO_2-e for biodiesel (table N.24).

Table N.24 **Implicit abatement subsidies[a]**
China, 2009

	Units	*Ethanol*	*Biodiesel*
Total subsidy equivalent	CNY m (2009)	11 184	549
	A$m (2010)	1 904	94
Total abatement	Mt CO_2-e	-0.3	0.2
Average implicit abatement subsidy	**CNY/t CO_2-e**	**-35 859**	**3 479**
	A$/t CO_2-e	**-6 105**	**592**

a The implicit abatement subsidy was not aggregated for ethanol and biodiesel due to the negative abatement result for ethanol.

Source: Productivity Commission estimates.

Sensitivity analysis

Sensitivity analysis was required for China due to uncertainty with regard to the life-cycle emissions intensity of ethanol by feedstock. Three scenarios are

presented — with the amount of abatement differing in each scenario for ethanol only (appendix M).

Life-cycle emissions intensity

The life-cycle emissions estimates for fuels in China are generally higher than estimates used for other study countries. This was most notably the case for ethanol. The relatively higher life-cycle emissions results were likely to be due to high fertiliser application rates during the planting of feedstock and energy-intensive refining ethanol processes (Ou et al. 2009). The central life-cycle emissions estimates used are sourced from a meta-analysis, which attempts to identify the most reliable life-cycle estimated of road transport fuels in China (Yan and Crookes 2009). These estimates do not include the impacts of land-use change.

However, as noted previously, the extent of abatement is highly sensitive to the method used to estimate life-cycle emissions and assumptions regarding the inclusion of land-use change or the treatment of recycled or waste feedstocks. Yan et al. (2009) conducted a meta-analysis of life-cycle studies for biofuels in China and calculated a range of emissions estimates for ethanol and petrol. Their upper-bound estimates for petrol and ethanol (produced using maize and cassava only, as they do not present a range for wheat) were used in the Commission's 'low' scenario for the sensitivity analysis.[6]

The NDRC (in GSI 2008b) and ERI (pers. comm., 11 May 2011) have stated that ethanol in China has 20 per cent less emissions than conventional petrol and that this is due to the use of stale grain as a feedstock. To take this possibility into account, a 'high' scenario is presented based on a situation where all ethanol has 20 per cent less emissions than petrol, on a life-cycle basis.

The sensitivity analysis shows that the estimated implicit abatement subsidy for ethanol is likely to lie in a range between -A$6105/t CO_2-e and A$2319/t CO_2-e depending on assumptions regarding the life-cycle emissions intensity of feedstocks used (table N.25).

6 Note the Commission's 'low' (and 'high') scenario does not refer to low (and high) estimates of life-cycle emissions.

Table N.25 **Sensitivity analysis, abatement (ethanol)**
China, 2009

Scenario	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Low	1 904	-1.4	-1 347
'Central'	1 904	-0.3	-6 105
High	1 904	0.8	2 319

Source: Productivity Commission estimates.

N.4 Germany

The Commission estimated the subsidy equivalent, abatement and implicit abatement subsidy for two biofuel policies in Germany: the *Biofuel Quota Act* (BioKraftQuG) and Energy Tax exemptions for biofuels. Both policies were analysed for calendar year 2009. It was assumed that no consumption or production of ethanol or biodiesel would take place in the absence of government support.

Abatement

Taking into account the different ethanol feedstocks used, the average abatement factor for ethanol was estimated to be 1593 g CO_2-e/L (petrol equivalent) (table N.26).

Table N.26 **Average abatement factor, ethanol**
Germany

Fuel type	*Feedstock*[a]	*Estimated production share*	*Life-cycle emissions intensity*
		%	g CO_2-e/L petrol equivalent
Ethanol	Grain	42	1 610
	Sugar cane	35	773
	Sugar beet	21	1 063
	Organic waste	2	322
	Weighted average	100	1 176
Petrol	Petroleum	100	2 769
Average abatement factor	**..**	**..**	**1 593**

[a] Life-cycle emissions estimates are those used by the German Government to estimate abatement (FMENCNS (Germany) 2010). These estimates do not distinguish between ethanol domestically produced using domestic feedstocks, ethanol domestically produced using imported feedstocks, and ethanol imported as a final product. **..** Not applicable.

Sources: FMENCNS (Germany) (2010); Appendix M. forgon

Taking into account the different biodiesel feedstocks used, the average abatement factor for biodiesel was estimated to be 1416 g CO_2-e/L (petrol equivalent) (table N.27).

Table N.27 **Average abatement factor, biodiesel**
Germany

Fuel type	*Feedstock*	*Estimated production share*	*Life-cycle emissions intensity*
		%	g CO_2-e/L petrol equivalent[a]
Biodiesel	Rapeseed oil	79	1 481
	Soybean oil	10	1 610
	Palm oil	5	1 030
	Recycled cooking oil	6	322
	Weighted average	100	1 402
Diesel	Petroleum	100	2 818
Average abatement factor	**..**	**..**	**1 416**

a Life-cycle emissions estimates are those used by the German Government to estimate abatement. These estimates do not distinguish between biodiesel domestically produced using domestic feedstocks, biodiesel domestically produced using imported feedstocks and biodiesel imported as a final product. **..** Not applicable.

Sources: FMENCNS (Germany) (2010); Appendix M.

Germany also consumes a significant amount of pure vegetable oil as transport fuel. When consumed in vehicles directly, vegetable oil tends to have somewhat lower emissions than biodiesel produced from the same feedstock because it requires less processing. All vegetable oil used directly for transport in 2009 was derived from rapeseed. Vegetable oil is usually blended with diesel, and diesel is therefore assumed to be the conventional fuel it displaces. The average abatement factor for vegetable oil was estimated to be 1691 g CO_2-e/L (petrol equivalent) (table N.28).

Table N.28 **Average abatement factor, vegetable oil**
Germany

Fuel type	*Feedstock*[a]	*Estimated production share*	*Life-cycle emissions intensity*
		%	g CO_2-e/L petrol equivalent
Biodiesel	Rapeseed oil	100	1 127
Diesel	Petroleum	100	2 818
Average abatement factor	**..**	**..**	**1 691**

a Life-cycle emissions estimates are those used by the German Government to estimate abatement. These estimates do not distinguish between vegetable oil domestically produced using domestic feedstocks, vegetable oil domestically produced using imported feedstocks and vegetable oil imported as a final product. **..** Not applicable.

Source: Appendix M.

Policy overlaps

The degree of policy overlap between the two biofuel policies discussed below differs by fuel type. The Biofuel Quota Act includes specific mandates for ethanol and biodiesel while the Energy Tax exemption applies to biodiesel, ethanol and vegetable oil. This means vegetable oil has no policy overlap. However, biodiesel and ethanol are affected by both policies. Hence, it was not possible to determine the incremental impacts of each policy on biodiesel or ethanol consumption. Instead, the subsidy equivalents, abatement and implicit abatement subsidies for each of the three fuel types individually, and for all three fuel types combined, are included in the 'whole-of-market' analysis at the end of this section.

Biofuel Quota Act

Since 2007, the Biofuel Quota Act has mandated minimum proportions of biofuels to be consumed as transport fuel, either neat or blended with petrol or diesel. Up until 2013, quotas are percentages of total fuel energy content. Table N.29 shows the quotas required in 2009 along with actual consumption of biofuels. As shown, the Act includes an overall quota of 5.25 per cent for all biofuels, a 4.4 per cent quota for biodiesel consumed in diesel and a 2.8 per cent quota for ethanol consumed in petrol (FMFACP (Germany) 2011).

Table N.29 **Biofuels, actual and mandated consumption**
Germany, 2009

Mandate coverage	*Mandated consumption share*	*Actual biofuel consumption*	*Actual conventional fuel consumption*	*Actual consumption share*[a]
	%	ML petrol equivalent	ML petrol equivalent	%
Biodiesel as a proportion of all diesel blends	4.40	2 904	34 604	7.7
Ethanol as a proportion of all petrol blends	2.80	754	25 752	2.9
Biofuel as a proportion of all transport fuels	5.25	3 775[b]	64 771[c]	5.8

a The actual consumption share is equal to actual biofuel consumption divided by the sum of actual biofuel consumption and actual conventional fuel consumption. **b** Includes biodiesel, ethanol and vegetable oil. This figure is sourced from FMENCNS (Germany) (2010). A slightly different figure (approximately 3923 ML) is provided by Energy Balances Working Group (2011). The difference does not affect the outcomes of the analysis. **c** Includes diesel, petrol, LPG and LNG. Sourced from Energy Balance Working Group (2011).

Sources: Energy Balances Working Group (2011); FMFACP (Germany) (2011); FMENCNS (Germany) (2010).

In 2009, actual biodiesel consumption was 7.7 per cent of all diesel blends by energy content. This suggests the mandate for biodiesel was not binding in that year. On the other hand, actual ethanol consumption was 2.9 per cent, just over the 2.8 per cent required by the mandate. The Commission considers that the ethanol mandate was binding. The overall biofuels mandate of 5.25 per cent was also significantly exceeded at 5.8 per cent. Overachievement of this overall mandate is most likely a consequence of higher than required consumption of biodiesel. The Commission considers that the overall biofuels mandate was therefore also not binding.

Energy Tax exemption for biofuels

The Energy Tax is a fuel excise on a variety of fuels used for electricity generation, heating and transport. The precise rates vary by fuel type. Following amendments in 2007, biodiesel and vegetable oil now receive only partial tax exemptions and these are being gradually reduced (FMF (Germany) 2011). There is no general tax exemption for ethanol, but the ethanol component of petrol blends with 70 per cent or more ethanol (for example, E85) is fully exempt, as is ethanol produced from cellulosic feedstocks. However, both of these ethanol exemptions are considered to have little impact on total ethanol consumption — ethanol eligible for these exemptions accounted for less than three per cent of total ethanol consumption in 2009.[7] In 2009, the tax exemptions received by biodiesel and vegetable oil were equivalent to production subsidies of €0.2734/L, and €0.3049/L respectively (FMJ (Germany) 2011).

'Whole-of-market' analysis

The following estimates take into account the combined effects of the Biofuel Quota Act and the Energy Tax exemptions for biofuels to provide an overall picture of the cost and abatement of biofuel policies in Germany.

7 E85 accounts for 0.9 per cent of total ethanol consumed in Germany (ARR (Germany) 2010). The precise proportion of ethanol produced using cellulosic feedstocks is unclear, but is no more than 2 per cent. Three major feedstocks (grain, sugar cane and sugar beet) account for 98 per cent of German ethanol production and these feedstocks are starch-based and sugar-based rather than cellulose-based (table N.26).

Estimating the total subsidy equivalent

Germany's biofuel policies affect the prices of ethanol, biodiesel and vegetable oil in different ways. This means different calculations are required to estimate the subsidy equivalent for each.

Biodiesel

Table N.30 shows the inputs used to calculate the subsidy equivalent for the market as a whole for biodiesel. Biodiesel is subject to policy overlap as it is affected by both of the policies discussed above. However, the biodiesel specific mandate under the Biofuel Quota Act was shown not to be binding during 2009. This means the subsidy equivalent for both policies combined can be calculated as if the Energy Tax exemption was the only policy affecting biodiesel. The subsidy equivalent for all biodiesel policies combined was therefore A$1.1 billion.

Table N.30 **Subsidy equivalent, biodiesel**
Germany, 2009

	Units	*Value*
Production subsidy equivalent	€/L	0.2734
Total consumption	ML	2 864
Total forgone government revenue	**€m (2009)**	**783**
Counterfactual consumption	ML	0
Policy-induced consumption	ML	2 864
Subsidy equivalent	**€m (2009)**	**783**
	A$m (2010)	**1 130**

Source: Productivity Commission estimates.

Ethanol

While certain types of ethanol are subject to Energy Tax exemptions, ethanol is also subject to a binding mandate. This means the inputs required to calculate the subsidy equivalent are different from those for biodiesel and required two steps. The first step was to calculate the production subsidy equivalent for ethanol (chapter 5). The production subsidy equivalent was estimated by calculating the difference between the terminal gate price (TGP) for ethanol and the TGP for petrol expressed in litres (petrol equivalent). This yielded an estimated production subsidy equivalent for ethanol of €0.49/L (petrol equivalent) (table N.31).

Table N.31 **Production subsidy equivalent, ethanol**

Germany, 2009

	Units	*Ethanol*	*Petrol*	*Production subsidy equivalent (difference)*
Market price (average 2009)	€/L	0.50[a]	0.30[b]	..
Freight and associated costs[c]	€/L	..	0.02[d]	..
Terminal costs and wholesale margin[e]	€/L	0.05	0.04	..
Estimated terminal gate price	€/L	0.55	0.36	..
Estimated energy adjusted terminal gate price	€/L petrol equivalent (2009)	0.85	0.36	0.49

a Anhydrous fuel ethanol, Central Europe delivered contract price sourced from F.O. Licht Interactive Database (accessed 23 April 2011). **b** Regular unleaded gasoline, Rotterdam export price sourced from F.O. Licht Interactive Database (accessed 23 April 2011). **c** Includes freight, insurance and wharfage. **d** Productivity Commission estimate using freight costs sourced from F.O. Licht Interactive Database (accessed 23 April 2011) and insurance and wharfage estimates used in Energy Quest (2010). **e** Using estimates applied for Australia in Energy Quest (2010). **..** Not applicable.

Sources: Energy Quest (2010); F.O. Licht Interactive Database (accessed 23 April 2011); Productivity Commission estimates.

The subsidy equivalent can then be estimated by multiplying the production subsidy equivalent by the total volume of ethanol consumption induced by the mandate. This value does not incorporate the subsidy equivalent of the tax exemptions as only the mandate is inducing consumption of ethanol. As shown in table N.32, the subsidy equivalent for the ethanol market as a whole was estimated to be A$533 million.

Table N.32 **Subsidy equivalent, ethanol**

Germany, 2009

	Units	*Value*
Production subsidy equivalent	€/L petrol equivalent	0.49
Total consumption	ML petrol equivalent	754
Counterfactual consumption	ML petrol equivalent	0
Policy-induced consumption	ML petrol equivalent	754
Subsidy equivalent	**€m (2009)**	**369**
	A$m (2010)	**533**

Source: Productivity Commission estimates.

Vegetable Oil

The Energy Tax exemption granted to vegetable oil is the only policy to support vegetable oil consumption as a biofuel. The subsidy equivalent for vegetable oil was

therefore the same as the subsidy equivalent for the Energy Tax exemption — A$48 million (table N.33).

Table N.33 **Subsidy equivalent, vegetable oil**
Germany, 2009

	Units	*Value*
Production subsidy equivalent	€/L	0.3049
Total consumption	ML	109
Forgone government revenue	**€m (2009)**	**33**
Counterfactual consumption	ML	0
Policy-induced consumption	ML	109
Subsidy equivalent	**€m (2009)**	**33**
	A$m (2010)	**48**

Sources: FMENCNS (Germany) (2010); Productivity Commission estimates.

Estimating total abatement

Total abatement was estimated to be 1.2 Mt CO_2-e for ethanol, 4.1 Mt CO_2-e for biodiesel and 0.2 Mt CO_2-e for vegetable oil (table N.34).

Table N.34 **Abatement, all biofuels**
Germany, 2009

	Units	*Ethanol*	*Biodiesel*	*Vegetable Oil*
Policy-induced consumption	ML	1 153	2 836	109
	ML petrol equivalent	754	2 904	117
Average abatement factor	g CO_2-e/L petrol equivalent	1 593	1 416	1 691
Abatement	**Mt CO_2-e**	**1.2**	**4.1**	**0.2**

Source: Productivity Commission estimates.

The average implicit abatement subsidy

The above estimates suggest an implicit abatement subsidy of A$444/t CO_2-e for ethanol, A$275/t CO_2-e for biodiesel and A$242/t CO_2-e for vegetable oil. The average implicit abatement subsidy — for all biofuel policies combined — was A$310/t CO_2-e (table N.35).

Table N.35 **Average implicit abatement subsidy, all biofuels**
Germany, 2009

	Units	*Ethanol*	*Biodiesel*	*Vegetable oil*	*Total*
Total subsidy equivalent	€m (2009)	369	783	33	1 186
	A$m (2010)	533	1 130	48	1 710
Total abatement	Mt CO_2-e	1.2	4.1	0.2	5.5
Average implicit abatement subsidy	**€/t CO_2-e**	**307**	**190**	**168**	**215**
	A$/t CO_2-e	**444**	**275**	**242**	**310**

Source: Productivity Commission estimates.

N.5 Japan

The Commission estimated the subsidy equivalent, abatement and implicit abatement subsidy for one biofuel policy in Japan: an exemption from the Gasoline Excise and Local Road Tax for ethanol. This policy was analysed for the fiscal year 2009 (April 2009 to March 2010). A second policy, an exemption from Diesel Handling Tax for biodiesel was also considered, but not estimated due to data limitations (discussed at the end of the section).

Abatement

Taking into account the different ethanol feedstocks used, the average abatement factor for ethanol was estimated to be 1576 g CO_2-e/L (petrol equivalent) (table N.36).

Policy overlaps

There are no policy overlaps between Japanese biofuel policies as only one policy was analysed. Given the assumption that no ethanol would be consumed without government assistance, this means all ethanol consumption was attributable to the ethanol fuel tax exemption.

Ethanol fuel tax exemption

Ethanol blended with petrol and used for transport fuel is exempt from the Gasoline Excise and the Local Road Tax on the portion of the blend made from ethanol. In fiscal year 2009, Gasoline Excise was paid at ¥48.6/L and Local Road Tax at

¥5.2/L. Combined, this equated to a production subsidy of ¥53.8/L for ethanol sold as transport fuel in Japan.

Table N.36 **Average abatement factor, ethanol**
Japan

Fuel type	*Feedstock*	*Estimated production share*[a]	*Life-cycle emissions intensity*
		%	g CO_2-e/L petrol equivalent
Ethanol	Rice (with water management)	3.2	2 950
	Rice (without water management)	3.2	1 844
	Waste wood	0.1	263
	Sugar beet	5.3	1 264
	Sugar cane (Brazil)	82.9	1 054[b]
	Wheat	5.3	1 422
	Weighted average	100.0	1 170
Petrol	Petroleum	100.0	2 747
Average abatement factor	**..**	**..**	**1 576**

[a] Feedstock shares are estimated based on production data by feedstock supplied by Institute of Energy Economics Japan (IEEJ, pers. comm., 20 April 2011). Where rice was identified as a feedstock the Commission assumed that half required water management. In the information provided by the IEEJ one plant identified sugar beet and wheat as feedstock. The Commission assumed that half of production came from each (see sensitivity analysis below). [b] This estimate assumes no change in land use. **..** Not applicable.

Sources: IEEJ (pers. comm., 20 April 2011); Appendix M.

Estimating the subsidy equivalent

The inputs used to estimate the subsidy equivalent are provided in table N.37 below. The subsidy equivalent was estimated to be A$57 million.

Table N.37 **Subsidy equivalent, ethanol fuel tax exemption**
Japan, April 2009 – March 2010

	Units	*Value*
Production subsidy equivalent	¥/L	53.8
Total consumption	ML	87
Forgone government revenue	**¥m (2009)**	**4 664**
Counterfactual consumption	ML	0
Policy-induced consumption	ML	87
Subsidy equivalent	**¥m (2009)**	**4 664**
	A$m (2010)	**57**

Sources: IEEJ (pers. comm., 14 April 2011); Productivity Commission estimates.

Estimating abatement

Total abatement due to the ethanol fuel tax exemption was estimated to be 90 kt CO_2-e (table N.38).

Table N.38 Abatement, ethanol fuel tax exemption
Japan, April 2009 – March 2010

	Units	*Value*
Policy-induced consumption	ML	87
	ML petrol equivalent	57
Average abatement factor	g CO_2-e/L petrol equivalent	1 576
Abatement	**Mt CO_2-e**	**0.09**

Source: Productivity Commission estimates.

The implicit abatement subsidy

The above estimates suggest that the implicit abatement subsidy for the ethanol fuel tax exemption was A$634/t CO_2-e (table N.39).

Table N.39 Implicit abatement subsidy, ethanol fuel tax exemption
Japan, April 2009 – March 2010

	Units	*Value*
Subsidy equivalent	¥m (2009)	4 664
	A$m (2010)	57
Abatement	Mt CO_2-e	0.09
Implicit abatement subsidy	**¥/t CO_2-e**	**51 910**
	A$/t CO_2-e	**634**

Source: Productivity Commission estimates.

Sensitivity analysis

Sensitivity analysis is required for Japan due to some uncertainty with regard to the life-cycle emissions intensity of several feedstocks.

There are two sources of uncertainty with regard to life-cycle emissions intensity in Japan. First, it is unclear whether the rice used to produce ethanol required water management. This has a significant impact on emissions intensity. In the 'central' estimate, it was assumed that half of the rice required water management and the other half did not (table N.40). In the high estimate, it was assumed that all rice

required water management. In the low estimate, it was assumed that no rice required water management.

The second source of uncertainty relates to a biodiesel plant that uses two feedstocks: sugar beet and wheat. In the central estimate, it was assumed that half the ethanol from this plant was produced from sugar beet and half from wheat. In the low estimate, it was assumed that all production was from sugar beet, and in the high estimate it was assumed that all production at this type of plant was from wheat.

The sensitivity analysis shows that the estimated implicit abatement subsidy is likely to lie in a range between A$617/t CO_2-e and A$653/t CO_2-e, depending on assumptions regarding the life-cycle emissions intensity of feedstocks used (table N.40).

Table N.40 **Sensitivity analysis, ethanol fuel tax exemption**
Japan, April 2009 – March 2010

Scenario	*Average abatement factor*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
	g CO_2-e/L petrol equivalent	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Low	1 620	57.0	0.092	617
Central	1 576	57.0	0.090	634
High	1 532	57.0	0.087	653

Source: Productivity Commission estimates.

Other Japanese biofuel policies

Diesel Handling Tax exemption for biodiesel

All diesel used as transport fuel in Japan is subject to a Diesel Handling Tax of ¥32.1/L. The biodiesel component of diesel blends is exempt from paying this tax. To estimate the subsidy equivalent for this policy would require an estimate of the total forgone revenue due to the exemption. The Commission has been unable to obtain such an estimate. Domestic production of biodiesel was estimated to be about 9 ML but the level of imports is uncertain because biodiesel used for road transport fuel is not counted separately from biodiesel for industrial use in Japan's trade statistics. Discussions with the Institute of Energy Economics of Japan (pers. comm., 27 April 2011) suggest imports of biodiesel for road transport use are likely to be very low. If all biodiesel produced domestically were consumed as transport fuel, biodiesel would only constitute about 0.01 per cent of total road transport fuel

consumption. This suggests that the subsidy equivalent of the policy would not have been significant if it were estimated.

N.6 New Zealand

The Commission estimated the subsidy equivalent, abatement and implicit abatement subsidy for two biofuel policies in New Zealand: the exemption of ethanol from some fuel taxes, and the Biodiesel Grants Scheme. Both policies were estimated for the 2010 calendar year. The default assumption of zero counterfactual consumption was used for ethanol and biodiesel in New Zealand.

Abatement

Taking into account the different ethanol feedstocks used, the average abatement factor for ethanol was estimated to be 1277 g CO_2-e/L (petrol equivalent) (table N.41).

Table N.41 **Average abatement factor, ethanol**
New Zealand

Fuel type	*Feedstock*	*Estimated production share*[a]	*Life-cycle emissions intensity*
		%	g CO_2-e/L petrol equivalent
Ethanol	Whey	60	2 016
	Sugar cane (imported from Brazil)	40	663
	Weighted average	100	1 475
Petrol	Petroleum	100	2 752
Average abatement factor	**..**	**..**	**1 277**

[a] Data on production by feedstock were not available, and thus feedstock production shares are estimates based on the main feedstocks used by active ethanol plants (EECA (NZ) 2011b). **..** Not applicable.

Sources: EECA (NZ) (2011b); Appendix M.

Taking into account the different biodiesel feedstocks used, the average abatement factor for biodiesel was estimated to be 2033 g CO_2-e/L (petrol equivalent) (table N.42).

Table N.42 **Average abatement factor, biodiesel**
New Zealand

Fuel type	*Feedstock*	*Estimated production share*[a]	*Life-cycle emissions intensity*
		%	g CO_2-e/L petrol equivalent
Biodiesel	Recycled cooking oil	95	736
	Rapeseed oil	5	1 957
	Weighted average	100	797
Diesel	Petroleum	100	2 830
Average abatement factor	**..**	**..**	**2 033**

a Data on production by feedstock were not available, and thus feedstock production shares are estimates based on the main feedstocks used by active biodiesel plants (EECA (NZ) 2011b). **..** Not applicable.

Sources: EECA (NZ) (2011b); Appendix M.

Policy overlaps

There are no policy overlaps between biofuel policies in New Zealand, as only one policy was analysed for each type of biofuel. Under the assumption that no biofuels would be consumed without government assistance, this means that all ethanol consumption is attributed to the exemption from some fuel taxes, and all biodiesel consumption is attributed to the Biodiesel Grants Scheme.

Ethanol fuel tax exemptions

There are several duties, taxes and direct levies on motor fuels in New Zealand. Regular unleaded petrol is subject to four different taxes: fuel excise, the Accident Compensation Corporation Levy, the Petroleum or Engine Fuels Monitoring Levy and the Local Authority Petroleum Tax. Fuel ethanol, either domestically produced or imported, is exempt from paying the first two of these taxes. On average, this means fuel ethanol was subject to NZ$0.56174/L less tax than petrol during the 2010 calendar year (MED (NZ) 2010a).

Estimating the subsidy equivalent

The inputs used to estimate the subsidy equivalent for the ethanol tax exemptions are provided in table N.43 below. The subsidy equivalent was estimated to be A$2.7 million.

Table N.43 **Subsidy equivalent, ethanol fuel tax exemptions**

New Zealand, 2010

	Units	*Value*
Production subsidy equivalent	NZ$/L	0.56174[a]
Total consumption	ML	6.3
Forgone government revenue	**NZ$m (2010)**	**3.5**
Counterfactual consumption	ML	0
Policy-induced consumption	ML	6.3
Subsidy equivalent	**NZ$m (2010)**	**3.5**
	A$m (2010)	**2.7**

[a] The fuel tax rate increased in October 2010 from NZ$0.55424 to NZ$0.58424. In the absence of quarterly data on fuel consumption, the production subsidy equivalent used here assumes that the average rate during 2010 was weighted according to the fraction of the year during which each rate was in place.

Sources: NZME (pers. comm., 15 April 2011); Productivity Commission estimates.

Estimating abatement

Abatement due to the fuel tax exemption was estimated to be 6 kt CO_2-e (table N.44).

Table N.44 **Abatement, ethanol fuel tax exemptions**

New Zealand, 2010

	Units	*Value*
Policy-induced consumption	ML	6.3
	ML petrol equivalent	4.5
Average abatement factor	g CO_2-e/L petrol equivalent	1 277
Abatement	**Mt CO_2-e**	**0.006**

Source: Productivity Commission estimates.

The implicit abatement subsidy

The above estimates suggest an implicit abatement subsidy for the ethanol fuel tax exemptions of A$479/t CO_2-e (table N.45).

Table N.45 **Implicit abatement subsidy, ethanol fuel tax exemptions**
New Zealand, 2010

	Units	*Value*
Subsidy equivalent	NZ$m (2010)	3.5
	A$m (2010)	2.7
Abatement	Mt CO_2-e	0.006
Implicit abatement subsidy	**NZ$/t CO_2-e**	**612**
	A$/t CO_2-e	**479**

Source: Productivity Commission estimates.

Biodiesel Grants Scheme

The Biodiesel Grants Scheme was introduced in July 2009. It provides a subsidy of NZ$0.425/L of biodiesel to domestic producers with sales of 10 000 litres per month or more (EECA (NZ) 2010). This subsidy somewhat offsets the Petroleum or Engine Fuels Monitoring Levy and Local Authority Petroleum Tax applicable to diesel and biodiesel and the Road User Charges applicable to diesel vehicles.

Estimating the subsidy equivalent

The inputs for estimating the subsidy equivalent are provided in table N.46. The subsidy equivalent for the Biodiesel Grants scheme was estimated to be A$0.4 million.

Table N.46 **Subsidy equivalent, Biodiesel Grants Scheme**
New Zealand, 2010

	Units	*Value*
Subsidy rate	NZ$/L	0.425
Total consumption	ML	1.1
Total subsidy expenditure	NZ$m (2010)	0.5
Counterfactual consumption	ML	0
Policy-induced consumption	ML	1.1
Subsidy equivalent	**NZ$m (2010)**	**0.5**
	A$m (2010)	**0.4**

Sources: EECA (NZ) (2010, 2011a); Productivity Commission estimates.

Estimating abatement

Total abatement due to the Biodiesel Grants Scheme was estimated to be 2 kt of CO_2-e (table N.47).

Table N.47 **Abatement, Biodiesel Grants Scheme**
New Zealand, 2010

	Units	*Value*
Policy-induced consumption	ML	1.1
	ML petrol equivalent	1.1
Average abatement factor	g CO_2-e/L petrol equivalent	2 033
Abatement	**Mt CO_2-e**	**0.002**

Source: Productivity Commission estimates.

The implicit abatement subsidy

The above estimates suggest an implicit abatement subsidy for the Biodiesel Grants Scheme of A$163/t CO_2-e (table N.48).

Table N.48 **Implicit abatement subsidy, Biodiesel Grants Scheme**
New Zealand, 2010

	Units	*Value*
Subsidy equivalent	NZ$m (2010)	0.5
	A$m (2010)	0.4
Abatement	Mt CO_2-e	0.002
Implicit abatement subsidy	**NZ$/t CO_2-e**	**209**
	A$/t CO_2-e	**163**

Source: Productivity Commission estimates.

Summary

The average implicit abatement subsidy

Combining the estimates above, the total subsidy equivalent was estimated to be A$3.1 million. Total abatement was estimated to be 8 kt CO_2-e and the average implicit abatement subsidy was estimated to be A$391/t CO_2-e (table N.49).

Table N.49 **Average implicit abatement subsidy**
New Zealand, 2010

	Units	*Ethanol*	*Biodiesel*	*Total*
Total subsidy equivalent	NZ$m (2010)	3.5	0.5	4.0
	A$m (2010)	2.7	0.4	3.1
Total abatement	Mt CO_2-e	0.006	0.002	0.008
Average implicit abatement subsidy	**NZ$/t CO_2-e**	**612**	**209**	**500**
	A$/t CO_2-e	**479**	**163**	**391**

Source: Productivity Commission estimates.

N.7 South Korea

The Commission estimated the subsidy equivalent, abatement and implicit abatement subsidy for one biofuel policy in South Korea: a biodiesel tax rebate. This policy was analysed for the 2010 calendar year and the default assumption of zero counterfactual consumption of biodiesel is applied.

Abatement

Available data to quantify abatement from biofuels in South Korea is very limited. The South Korean Government does not publish data on the life-cycle emissions intensity of different fuels (KEEI, pers. comm., 26 April 2011). Furthermore, the Commission is not aware of any peer-reviewed studies of the life-cycle emissions intensity of fuels in South Korea.

The emissions intensity figures in the table below rely on estimates drawn from a number of sources. For diesel, and for biodiesel derived from domestic feedstock (recycled cooking oil), Japanese estimates were used. For biodiesel derived from imported feedstock, emissions intensities were estimated by the Commission using the UK Renewable Fuel Agency's Carbon Calculator (appendix M).

Taking into account the different biodiesel feedstocks used, the average abatement factor for biodiesel was estimated to be 771 g CO_2-e/L of diesel equivalent (table N.50).

Table N.50 **Average abatement factor, biodiesel**

South Korea

Fuel type	*Feedstock*[a]	*Estimated production share*	*Life-cycle emissions intensity*[b]
		%	g CO2-e/L petrol equivalent
Biodiesel	Palm oil (imported from Indonesia or Malaysia)	48	2 298
	Soybean oil (imported from Brazil or Argentina)	23	2 325
	Recycled cooking oil	21	375
	Other (imported)	8	2 325[c]
	Weighted average	100	1 903
Diesel	Petroleum	..	2 673
Average abatement factor	**..**	**..**	**771**

[a] While feedstock shares were provided by KEEI (pers. comm., 18 April 2011), the country of origin of imported feedstocks was unknown. The origins of imported feedstocks used here are based on information provided in FAS (US) (2010b). [b] Figures for imported feedstocks are estimates generated using the Renewable Fuels Agency (RFA) (2010) Carbon Calculator; the figure for recycled cooking oil is from Singhabhandhu, Kurosawa and Tezuka (2006); the figure for diesel is from MIRI (2004). [c] 'Other' is assumed to have the same emissions intensity as imported palm oil, the feedstock with the highest emissions intensity. **..** Not applicable.

Sources: FAS (US) (2010b); KEEI (pers. comm., 18 April 2011); MIRI (2004); RFA (2010); Singhabhandhu, Kurosawa and Tezuka (2006); Appendix M.

Policy overlaps

There are no policy overlaps between South Korean biofuel policies, as only one policy is analysed. Given the assumption that no biodiesel would be consumed without government assistance, this means all biodiesel consumption is attributable to the tax rebate.

Biodiesel tax rebate

The biodiesel tax rebate entitles domestic producers and importers of biodiesel to KRW 528.75/L of biodiesel sold. The rebate is offered in order to meet a 2010 government target that biodiesel constitute two per cent of total diesel sales (KEEI, pers. comm., 18 April 2011).

Estimating the subsidy equivalent

The inputs for estimating the subsidy equivalent are provided in table N.51 below. The subsidy equivalent was estimated to be A$196 million.

Table N.51 **Subsidy equivalent, biodiesel tax rebate**

South Korea, 2010

	Units	*Value*
Production subsidy equivalent	KRW/L	528.75
Total consumption	ML	395
Forgone government revenue	**KRW b (2010)**	**209**
Counterfactual consumption	ML	0
Policy-induced consumption	ML	395
Subsidy equivalent	**KRW b (2010)**	**209**
	A$m (2010)	**196**

Sources: KEEI (pers. comm., 26 April 2011); Productivity Commission estimates.

Estimating abatement

Total abatement due to the biodiesel tax rebate was estimated to be 0.3 Mt CO_2-e (table N.52).

Table N.52 **Abatement, biodiesel tax rebate**

South Korea, 2010

	Units	*Value*
Policy-induced consumption	ML	395
	ML petrol equivalent	401
Average abatement factor	g CO_2-e/L petrol equivalent	771
Abatement	**Mt CO_2-e**	**0.3**

Source: Productivity Commission estimates.

The implicit abatement subsidy

The above estimates suggest an implicit abatement subsidy for the biodiesel tax rebate of A$635/t CO_2-e (table N.53).

Table N.53 **Implicit abatement subsidy, biodiesel tax rebate**

South Korea, 2010

	Units	*Value*
Subsidy equivalent	KRW b (2010)	209
	A$m (2010)	196
Abatement	Mt CO_2-e	0.3
Implicit abatement subsidy	**KRW/t CO_2-e**	**675 837**
	A$/t CO_2-e	**635**

Source: Productivity Commission estimates.

Sensitivity analysis

There is a significant degree of uncertainty with regard to the life-cycle emissions intensity of South Korean diesel and biodiesel due to a lack of South Korea-specific estimates. Sensitivity analysis was used to show the effect of varying emissions intensity values.

The sensitivity analysis altered the central estimate in two ways:

1. In the central estimate, the diesel emissions intensity figure for Japan is used for South Korea (appendix M). Japan's estimate is actually the lowest of the study countries. As an alternative estimate, the low estimate below assumes an emissions intensity approximately equivalent to the average estimate for other study countries (2900 g CO_2-e/L petrol equivalent).
2. The central estimate relies on emissions intensity figures for imported feedstocks estimated by the Commission using the default emissions figures in the UK Renewable Fuel Agency's Carbon Calculator. To reflect uncertainty in these calculations the low estimate assumes emissions intensity figures 10 per cent lower and the high estimate assumes emissions intensity figures 10 per cent higher than those in the central estimate.

The sensitivity analysis shows that the estimated implicit abatement subsidy is likely to lie in a range between A$415—A$831/t CO_2-e depending on assumptions regarding the life-cycle emissions intensity of feedstocks used (table N.54).

Table N.54 **Sensitivity analysis, biodiesel tax rebate**
South Korea, 2010

Scenario	*Average abatement factor*	*Subsidy equivalent*	*Total abatement*	*Implicit abatement subsidy*
	g CO_2-e/L petrol equivalent	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Low	1 180	196	0.5	415
'Central'	771	196	0.3	635
High	588	196	0.2	831

Source: Productivity Commission estimates.

N.8 United Kingdom

The Commission estimated the subsidy equivalent, abatement and implicit abatement subsidy for one biofuel policy in the United Kingdom: the Renewable Transport Fuels Obligation (RTFO). This policy was analysed for fiscal year 2009 (April 2009 to March 2010). In estimating the subsidy equivalent and abatement for the United Kingdom, the Commission assumed that there would be no domestic production or consumption of biofuel without government assistance.

Abatement

Taking into account the different ethanol feedstocks used, the average abatement factor for ethanol was estimated to be 1709 g CO_2-e/L (petrol equivalent) (table N.55) and the average abatement factor for biodiesel is 1356 g CO_2-e/L (petrol equivalent) (table N.56).

Table N.55 **Average abatement factor, ethanol**
United Kingdom

Fuel type	*Feedstock*	*Estimated production share*	*Life-cycle emissions intensity*
		%	g CO_2-e/L petrol equivalent
Ethanol	Barley	0.1	3 477
	Cassava	0.03	3 772
	Maize	3	1 605
	Molasses	1.3	1 851
	Sugar beet	16.6	708
	Sugar cane	67.7	803
	Triticale	0.3	2 167
	Wheat	8	2 108
	Unknown	2.9	3 772
	Weighted average	100	1 023
Petrol	Petroleum	100	2 732
Average abatement factor	**..**	**..**	**1 709**

.. Not applicable.

Sources: RFA (2010b); Appendix M.

Table N.56 **Average abatement factor, biodiesel**
United Kingdom

Fuel type	*Feedstock*	*Estimated production share*	*Life-cycle emissions intensity*
		%	g CO_2-e/L petrol equivalent
Biodiesel	Maize	0.01	590
	Rapeseed oil	22.5	1 956
	Palm oil	8.9	1 518
	Soybean oil	43.1	1 650
	Sunflower oil	0.02	2 207
	Tallow	16.4	511
	Recycled cooking oil	3.8	427
	Unknown	5.3	3 043
	Weighted average	100	1 547
Diesel	Petroleum	100	2 903
Average abatement factor	**..**	**..**	**1 356**

.. Not applicable.

Sources: RFA (2010b); Appendix M.

Policy interaction

There is no policy interaction between UK biofuel policies as only one policy is in place. As the Commission assumed that without government assistance no biofuel would be consumed in the United Kingdom, all biofuel consumed in fiscal year 2009 in the United Kingdom was assumed to be induced by the RTFO.

Renewable Transport Fuels Obligation

The RTFO requires domestic refineries and importers of refined conventional fuels to ensure that a specified percentage of the road fuels supplied in the United Kingdom are renewable fuels. The target for fiscal year 2010 is 3.5 per cent by volume of fuel.

Road transport fuel suppliers are required to submit Renewable Transport Fuel Certificates at the end of the year to meet their obligation. Suppliers can obtain these certificates by either supplying biofuels to the UK market or by trading with

other biofuel suppliers.[8] Suppliers also have the option of buying out their obligations under the RTFO (£0.15/L in fiscal year 2009).[9]

The RTFO applies to the whole of the United Kingdom and covers the supply of fuels for road transport use only. The biofuels eligible for support under the RTFO include ethanol, biodiesel, and biogas. Analysis has not been conducted for biogas because it accounts for an insignificant proportion of total biofuel consumed (RFA 2010b).

Estimating the subsidy equivalent

The annual target for fiscal year 2009 was for biofuel to constitute 3.25 per cent of total road transport fuels supplied to the market. Total consumption of biofuels in fiscal year 2009 was 1568 ML (comprising 455 ML of ethanol and 1113 ML of biodiesel) (RFA 2010b). This represents 3.33 per cent of total road transport fuels consumed in the United Kingdom in fiscal year 2009, meaning the mandate for this period was exceeded by 40 ML or 0.08 per cent. Given that actual consumption was so close to the mandated level, the mandate was treated as binding in the analysis.

The production subsidy equivalent for a litre of biofuel is the difference between the TGP for ethanol and the TGP for petrol expressed in litres of petrol equivalent (chapter 5). This yielded an estimated production subsidy equivalent for ethanol of £0.41/L (petrol equivalent) (table N.57).

Applying the same approach to biodiesel yielded an estimated production subsidy equivalent of £0.24/L (petrol equivalent) (table N.58).

The subsidy equivalent was then calculated by multiplying the production subsidy equivalent by the amount of policy-induced consumption (in litres of petrol equivalent). As all biofuel consumption in the United Kingdom was attributed to the RTFO, policy-induced consumption equals the total volume of biofuels consumed in fiscal year 2009.

8 One Renewable Transport Fuel Certificate is awarded for every litre of biofuel reported to the Renewable Fuels Agency.

9 This increased to £0.30/L for fiscal year 2010.

Table N.57 **Production subsidy equivalent, ethanol**

United Kingdom, April 2009 – March 2010

	Units	*Ethanol*[a]	*Petrol*[b]	*Implicit subsidy (difference)*
Market price (average 2009-10)	£/L	0.45[c]	0.30[d]	..
Freight and associated costs[c]	£/L	0.01	0.01	..
Terminal costs and wholesale margin[d]	£/L	0.04	0.03	..
Estimated TGP[e]	£/L	0.50	0.34	..
Estimated energy adjusted TGP	£/L petrol equivalent (2009)	0.76	0.34	0.41

a Anhydrous fuel ethanol, North Europe delivered contract price sourced from F.O. Licht Interactive Database (accessed 23 April 2011). **b** Regular unleaded gasoline, Rotterdam export price sourced from F.O. Licht Interactive Database (accessed 23 April 2011). **c** Productivity Commission estimate of freight, insurance and wharfage costs using freight costs sourced from F.O. Licht Interactive Database (accessed 23 April 2011) and insurance and wharfage estimates used in Energy Quest (2010). **d** Using estimates applied for Australia in Energy Quest (2010). **e** The energy adjustment of terminal gate prices used general European energy content figures because the market prices used in the analysis refer to fuel in Northwest Europe rather than the United Kingdom specifically (JEC-EUCAR-CONCAWE 2008a) . **..** Not applicable.

Sources: Energy Quest (2010); F.O. Licht Interactive Database (accessed 23 April 2011); JEC-EUCAR-CONCAWE 2008a; Productivity Commission estimates.

Table N.58 **Production subsidy equivalent, biodiesel**

United Kingdom, April 2009 – March 2010

	Units	*Biodiesel*	*Diesel*	*Implicit subsidy (difference)*
Market price (average 2009-10)	£/L	0.52[a]	0.31[b]	..
Freight and associated costs[c]	£/L	0.01	0.01	..
Terminal costs and wholesale margin[d]	£/L	0.04	0.03	..
Estimated TGP[e]	£/L	0.57	0.35	..
Estimated energy adjusted TGP	£/L petrol equivalent (2009-10)	0.55	0.31	0.24

a Weighted average of Rotterdam Biodiesel (fatty acid methyl ester) export prices to reflect UK standards that require biodiesel with different cold filter plugging points at different times of the year sourced from F.O. Licht Interactive Database (accessed 23 April 2011). **b** Diesel, Northwest Europe price sourced from F.O. Licht Interactive Database (accessed 23 April 2011). **c** Productivity Commission estimate of freight, insurance and wharfage costs using freight costs sourced from F.O. Licht Interactive Database (accessed 23 April 2011) and insurance and wharfage estimates used in Energy Quest (2010). **d** Using estimates applied for Australia in Energy Quest (2010). **e** The energy adjustment of terminal gate prices used general European energy content figures because the market prices used in the analysis refer to fuel in Northwest Europe rather than the United Kingdom specifically (JEC-EUCAR-CONCAWE 2008a). **..** Not applicable.

Sources: Energy Quest (2010); F.O. Licht Interactive Database (accessed 23 April 2011); JEC-EUCAR-CONCAWE 2008a; Productivity Commission estimates.

As shown in table N.59, the subsidy equivalent for the RTFO was estimated to be A$209 million for ethanol, A$465 million for biodiesel and A$674 million for both fuels combined.

Table N.59 **Subsidy equivalent, RTFO**

United Kingdom, April 2009 – March 2010

	Units	*Ethanol*	*Biodiesel*	*Total*
Production subsidy equivalent	**£/L petrol equivalent**	**0.41**	**0.24**	**0.65**
Total consumption	ML fuel	455	1 113	**..**
	ML petrol equivalent	296	1 123	1 419
Counterfactual consumption	ML petrol equivalent	0	0	0
Policy-induced consumption	ML petrol equivalent	296	1 123	1 419
Subsidy equivalent	**£m (2009-10)**	**121**	**270**	**391**
	A$m (2010)	**209**	**465**	**674**

.. Not estimated

Sources: RFA (2010b); Productivity Commission estimates.

Estimating abatement

Abatement from the RTFO was estimated to be 0.5 Mt CO_2-e for ethanol and 1.5 Mt CO_2-e for biodiesel (table N.60). Total abatement was estimated to be 2.0 Mt CO_2-e.

Table N.60 **Abatement, RTFO**

United Kingdom, April 2009 – March 2010

	Units	*Ethanol*	*Biodiesel*	*Total*
Policy-induced consumption	ML	455	1 113	..
	ML petrol equivalent	296	1 123	1 419
Average abatement factor	g CO_2-e/L petrol equivalent	1 709	1 356	..
Abatement	**Mt CO_2-e**	**0.5**	**1.5**	**2.0**

.. Not estimated

Source: Productivity Commission estimates.

The implicit abatement subsidy

The implicit abatement subsidy was estimated to be A$414/t CO_2-e for ethanol, A$305/t CO_2-e for biodiesel and A$332/t CO_2-e overall (table N.61).

Table N.61 **Implicit abatement subsidy, RTFO**
United Kingdom, April 2009 – March 2010

	Units	*Ethanol*	*Biodiesel*	*Total*
Subsidy equivalent	£m (2009-10)	121	270	391
	A$m (2010)	209	465	674
Abatement	Mt CO_2-e	0.5	1.5	2.0
Implicit abatement subsidy	**£/t CO_2-e**	**240**	**177**	**193**
	A$/t CO_2-e	**414**	**305**	**332**

Source: Productivity Commission estimates.

N.9 United States

The Commission estimated the subsidy equivalent, abatement and implicit abatement subsidy for policies that support the consumption of biofuel in the United States. There are more biofuel policy measures in the United States than in any other study country. These include the Alcohol and Biodiesel Fuel Credits, the Bioenergy Program for Advanced Biofuels, the Biorefinery Assistance Program, state excise concessions for ethanol, the Renewable Fuel Standard, state-level fuel standards, and the Federal Fleet Management Guidance.

Where possible, the subsidy equivalent was estimated for each of these policies. In doing so, the default assumption was that no biofuel would be consumed in the absence of any policy measures — that is, counterfactual consumption of zero. (However, as reflected in the sensitivity analysis presented below, it is possible that some biofuel would be consumed without policy support as ethanol is added to petrol meet to air quality requirements in some parts of the United States.)

The analysis was conducted for US fiscal year 2009 (October 2008 to September 2009), although in some cases it was only possible to provide estimates over calendar year 2009.

Abatement

Taking into account the different feedstocks used to produce biofuels, the average abatement factor for ethanol in the United States was estimated to be 832 g CO_2-e/L (petrol equivalent) (table N.62). The average abatement factor for biodiesel was estimated to be 2318 g CO_2-e/L (petrol equivalent) (table N.63).

Table N.62 **Average abatement factor, ethanol**

United States

Fuel type	*Feedstock*	*Estimated production share*[a]	*Life-cycle emissions intensity*[b]
		%	g CO_2-e/L petrol equivalent
Ethanol	Maize starch	97.17	2 116
	'Cellulosic'[c]	0.98	174
	Sugar cane	1.85	775
	Weighted average	100	2 072
Petrol	Petroleum	100	2 904
Average abatement factor	**..**	**..**	**832**

a Feedstock shares were estimated by assuming that all imported ethanol in 2009 was derived from sugar cane. Of the remainder, the Commission assumed that 1 per cent is 'cellulosic' ethanol and that the remainder was produced from maize starch. This is consistent with domestic production figures reported by the Renewable Fuels Association (2011). **b** The value for cellulosic ethanol is from the ANL (US) (2010). All other values are also from the ANL (US) (2011). **c** 'Cellulosic' ethanol refers to ethanol produced from cellulose, hemicellulose or lignin (that is, not from plant starches or sugars). **..** Not applicable.

Sources: ANL (US) (2010, 2011); Renewable Fuels Association (2011); Appendix M.

Table N.63 **Average abatement factor, biodiesel**

United States

Fuel type	*Feedstock*	*Estimated production share*	*Life-cycle emissions intensity*
		%	g CO_2-e/L petrol equivalent
Biodiesel[a]	Soybean oil	100	669
Diesel	Petroleum	100	2 988
Average abatement factor	**..**	**..**	**2 318**

a As data on biodiesel consumption by feedstock share were not available, the Commission assumed that most biodiesel used in the United States is derived from soybean oil. This is the only feedstock for which an emissions intensity value was available in the Greenhouse Gases, Regulated Emissions and Energy Use in Transportation Model (ANL (US) 2011). **..** Not applicable.

Sources: ANL (US) (2011); Appendix M.

Policy overlaps

As noted, there are a range of policy measures that support the use of biofuels in the United States. These consist of subsidies for domestic producers, tax concessions for the sale of biofuel, and fuel content mandates that require that road transport fuels contain a certain percentage of biofuel.

Most biofuels consumed in the United States are likely to benefit from multiple policy measures. As a result, it was not possible to determine the impact that each individual policy has on the overall level of consumption (and thus abatement). This means that estimates of the subsidy equivalent, abatement and implicit abatement subsidy have not been provided for each individual policy. Rather, the Commission has used a 'whole-of-market' analysis to examine the effects of all policies, considered together (with separate analyses that cover ethanol and biodiesel).

The total volumes of ethanol and biodiesel that are consumed in the United States are generally determined each year by the Renewable Fuel Standard (RFS) — a fuel content mandate. This standard is met mainly through the use of domestically produced biofuel, as well as a relatively small volume of imports (table N.64). However, other policies can change the mix of domestic production and imports that are used to meet the mandate. For example, the share of domestic production could be raised by tax credits that are provided to ethanol producers (Alcohol Fuel Credits), or the tariff on most ethanol imports. Where policies (in addition to the RFS) favour domestic producers, they can lead to substitution from imports towards higher-cost domestic production. This substitution could also affect abatement outcomes depending on the feedstocks that are used domestically and to produce imports.

Table N.64 **Biofuel consumption**[a]

United States, 2009

	Ethanol		*Biodiesel*	
	ML	%	ML	%
Total consumption[b]	40 596	100	1 198	100
Domestically produced	40 500	98	910	76
Imported[c]	750	2	293	24
RFS targets[d]	40 125	..	1 893	..

a All figures are for fuel ethanol (that is, ethanol used as transport fuel). **b** Values may not sum to total perfectly due to the accumulation of stocks (EIA (US) 2011k). **c** The United States was a net importer of ethanol, and a net exporter of biodiesel, in 2009. **d** An overall target of 11.1 billion gallons was set, of which the US EPA (2008b) expected 0.5 billion gallons to consist of biodiesel. The remainder has been attributed to ethanol in the table. **..** Not applicable.

Sources: EIA (US) (2011k); US EPA (2008b).

A 'whole-of-market' subsidy equivalent was estimated for ethanol and biodiesel in the United States by adding up the subsidy equivalent of a range of policies that support the consumption of biofuels (whether produced domestically or sourced from imports). This consists of government expenditure on explicit subsidies, forgone revenue from tax concessions, and the benefit that arises from policies that raise the price of biofuels relative to conventional fuels. The 'whole-of-market'

estimates are then divided by abatement (for each of ethanol and biodiesel) to calculate implicit abatement subsidies. In other words, estimates are provided for both types of biofuel at an aggregated level, given the difficulty in estimating abatement for each separate policy measure.

The following sections discuss each major biofuel policy in the United States, including estimates of the subsidy equivalent where possible.

Alcohol and Biodiesel Fuel Credits

Alcohol and Biodiesel Fuel Credits are subsidies, provided as tax credits, for producers of ethanol and biodiesel used as transport fuels. These credits can be used to offset income taxes or federal-level fuel excise, and can only be claimed for biofuels that are both produced and consumed in the United States. The current rates have applied since 1 January 2009.

The subsidy rates are US$0.45/gallon (US$0.12/L) of ethanol and US$1.00/gallon (US$0.26/L) of biodiesel or 'renewable diesel'.[10] Additional tax credits are provided to producers of 'cellulosic ethanol', such that the total rate is US$1.01/gallon (US$0.27/L) (IRS (US) 2009a; CBO (US) 2010). A small producer credit is also provided to producers with an annual refining capacity of 60 million gallons or less (IRS (US) 2009a). These small producers receive an additional US$0.10 per gallon (US$0.04/L) over the first 15 million gallons of biofuel produced each year.

In fiscal year 2009, the subsidy equivalent — measured as forgone revenue — was A$5.7 billion for ethanol and A$922 million for biodiesel (OMB (US) 2011). Overall, the subsidy equivalent was A$6.6 billion (table N.65).

10 These payments are for either the production of straight biofuel, or for biofuels that are blended with petrol or diesel. The tax credit for ethanol that is used in petrol blends is often referred to as the Volumetric Ethanol Excise Tax Credit.

Table N.65 **Subsidy equivalent, Alcohol and Biodiesel Fuel Credits**
United States, October 2008 – September 2009

Fuel type	*Domestic production*[a]	*Subsidy equivalent*	
	ML petrol equivalent	US$m (2009)	A$m (2010)
Ethanol	26 656	5 210	5 718
Biodiesel	623	840	922
Total	**27 279**	**6 050**	**6 640**

[a] Calculated by assuming that all ethanol and biodiesel production in the United States (that is not exported) is eligible for the tax credits. Values for each fuel type are from the EIA (US) (2011k).

Sources: EIA (US) (2011k); OMB (US) (2011).

Bioenergy Program for Advanced Biofuels

The Bioenergy Program for Advanced Biofuels (also known as the 'Advanced Biofuel Payment Program' or 'Section 9005 Program') subsidises the production of 'advanced biofuels'. These include most types of ethanol and biodiesel, excluding ethanol produced from maize starch (USDA 2010b). The program also provides subsidies for other products that are not used as road transport fuels (biogas and wood pellets).

Payments are made annually, based on the level of production and the feedstocks used by eligible producers. Payment rates differ depending on the feedstocks used and the size of the facility (rates are lower for producers with an annual capacity of 150 million gallons or greater). There are also different payment rates for 'base' production (equal to total production over the previous year) and 'incremental' production (additional production within the year) (USDA 2010b).

In fiscal year 2009, a total of US$14.7 million was paid to biofuel producers through the Bioenergy Program. Of this amount, US$13.8 million was paid to producers of ethanol and biodiesel (USDA 2010b) (table N.66).

The subsidy equivalent for ethanol is thus A$8.0 million, and that for biodiesel is A$7.1 million.

Table N.66 **Subsidy equivalent, Bioenergy Program**

United States, October 2008 – September 2009

Main feedstock type[a]	*Total base production*	*Total incremental production*	*Total reported production*	*Subsidy equivalent (total payments)*	
	ML petrol equivalent	ML petrol equivalent	ML petrol equivalent	US$m (2009)	A$m (2010)
Ethanol	567	284	851	7.3	8.0
Sorghum	518	264	782	6.8	7.5
Other	50	20	70	0.5	0.5
Biodiesel	943	35	979	6.5	7.1
Tallow or greases	296	19	315	2.0	2.2
Recycle vegetable oil	82	12	94	0.6	0.6
Soybean oil	274	1	274	1.6	1.7
Rapeseed oil	164	0.4	164	1.5	1.6
Other	127	3	130	0.9	1.0
Total	**1 511**	**319**	**1 830**	**13.8**	**15.2**

[a] Where multiple feedstocks were listed by USDA (2010b) for an individual producer, the first feedstock listed was used to assign payments to a category in the table.

Sources: USDA (2010b); Productivity Commission estimates.

Biorefinery Assistance Program

The Biorefinery Assistance Program (also referred to as the 'Section 9003 Program') provides government assistance for the establishment or retrofitting of refineries that produce 'advanced biofuels'. This assistance consists of:

- grants for demonstration-scale projects
- loan guarantees for commercial-scale facilities that use technologies that have previously been deployed at a commercial scale, or that 'have been demonstrated to have technical and economic potential for commercial application' (USDA 2008).

In the latter case, the maximum size of the loan guarantee that can be provided depends on the size of the loan. The guaranteed amount is 80 per cent (of the principal and interest) for loans of US$80 million or less, and decreases to 60 per cent (of the entire loan amount) for loans of US$125 million or greater (USDA 2008). In some circumstances, the maximum amount can be increased to 90 per cent (USDA 2011).

In fiscal year 2009 (the first year of the scheme), US$75 million in funding had been authorised. According to the US Department of Agriculture, two projects had received loan guarantees as of November 2010 (USDA 2010a). These covered a US$80 million loan to Range Fuels for the production of biomass-derived methanol,

and a US$54.5 million loan to Sapphire Energy to produce biofuels from algae (USDA 2010b). Both projects also received funding from the US Department of Energy.

However, the loan guarantee for Sapphire Energy was not announced until December 2009, and that for Range Fuels was not announced until March 2010 (Sapphire Energy 2009; Range Fuels 2010). It is thus unclear whether any biofuels were produced at these facilities in 2009. As a result, a subsidy equivalent could not be calculated for this policy.

State excise concessions for ethanol

In some US states (but not at the federal level), ethanol is taxed at a lower rate than petrol (table N.67). This effectively subsidises the use of ethanol in these states (irrespective of whether this ethanol is domestically produced or imported). These tax concessions are often applied to the two ethanol–petrol blends that can be legally sold in the United States — E10 (petrol blended with 10 per cent ethanol, also called 'gasohol' in the United States) and E85 (petrol blended with 85 per cent ethanol). By contrast, other states (and the federal government) tax E10 at the same rate as petrol.

The total forgone revenue from these tax concessions can be calculated by multiplying an estimate of the amount of E10 consumed in each state by the difference between the petrol tax and the E10 tax (table N.68). (This calculation has not been done for E85 due to the very small volume consumed.)

This suggests that, over the ten states, the subsidy equivalent to ethanol (the value of forgone revenue) was A$3.0 billion in 2009. (As data for ethanol consumption in each state were not available for fiscal year 2009, data for the 2009 calendar year were used in the analysis.)

Table N.67 **State excise concessions for ethanol[a]**

United States, 2009

State	*Tax on E10*	*Tax on petrol*
	US$/gallon	US$/gallon
District of Columbia	0.20	0.235
Hawaii	0.16	0.17
Iowa	0.19	0.21
Maine	0.23	0.295
Maryland	–	0.235
Michigan	–	0.19
Montana	0.23	0.27
New York	–	0.2515
South Dakota	0.08	0.22
Vermont	–	0.20

a Volumetric state-level fuel taxes as of December 2009. **–** Nil or rounded to zero.

Source: FHWA (US) (2011a).

Renewable Fuel Standard

The Renewable Fuel Standard sets the minimum volume of biofuels that must be sold in the United States each year. This volume — expressed in billions of gallons — increases each year according to a schedule, which is converted to a percentage value each year (that is, the volume of ethanol or biodiesel expressed as a percentage of the total amount of petrol or diesel sold[11]). The requirements are met through the creation of certificates (Renewable Identification Numbers), which can be traded between fuel refiners and importers to meet their obligations (US EPA 2010c).

Mandates for 'renewable fuels' were first set in 2008, with an initial requirement that a total of 9 billion gallons (34 billion litres) of ethanol be blended into petrol (US EPA 2007b, 2008b). Following the passage of legislation in 2007, the scheme was then expanded (to form 'RFS2'). This meant that, from 2010 onwards, both petrol and diesel would be subject to the RFS. An overall target was set for 36 billion gallons (136 billion litres) of biofuel to be sold in 2022, of which 21 billion gallons (79 billion litres) must be cellulosic ethanol or other 'advanced' biofuels (that is, not maize starch).

11 This percentage is set at the aggregate level (over the total volume of fuels sold). No particular types of blends are set by the RFS, although in practice the mandate is met by the use of E10 and B2 (diesel containing 2 per cent biodiesel).

Table N.68 **Subsidy equivalent, state excise concessions for E10**

United States, 2009

State	*Tax on petrol*	*Tax on E10*	*Difference in tax rates*	*E10 consumption*[a]	*Subsidy equivalent (forgone revenue)*
	US$/L	US$/L	US$/L	ML	US$m (2009)
District of Columbia	0.062	0.053	0.009	251	2
Hawaii	0.045	0.042	0.003	1 633	4
Iowa	0.055	0.050	0.005	3 381	18
Maine	0.078	0.061	0.017	2 367	41
Maryland	0.062	0.000	0.062	8 213	510
Michigan	0.050	0.000	0.050	15 993	803
Montana	0.071	0.061	0.011	1174	12
New York	0.066	0.000	0.066	18 855	1 253
South Dakota	0.058	0.021	0.037	1 496	55
Vermont	0.053	0.000	0.053	1 172	62
Total	**..**	**..**	**..**	**54 534**	**2 760**

a E10 consumption was estimated by assuming that all ethanol consumed in each state is used in E10 fuel blends. **..** Not applicable.

Sources: FHWA (US) (2011a); EIA (US) (2011p).

In addition, specific targets were set for each year for certain types of biofuel, namely cellulosic biofuel, biomass-based diesel and other 'advanced' biofuel (US EPA 2010b) (table N.69). To qualify for one of these categories, biofuels must be produced using certain feedstocks and achieve a minimum reduction in life-cycle greenhouse gas emissions, which is assessed using formulae set by the US Environmental Protection Agency (US EPA 2010b).

Impacts on total biofuel consumption

When the RFS was first introduced in 2008, the consumption of ethanol rose from 25 billion litres (in 2007) to 36 billion litres (in 2008) (EIA (US) 2011k). This increase actually exceeded the mandated level of 20.4 billion litres (US EPA 2007a). However, the high level of biofuel consumption prior to the mandate, and in the first year, may be due to other policy measures, such as subsidies for ethanol producers.

However, since 2009, the RFS has generally determined the amount of biofuel that is consumed in the United States each year. In 2009, the requirement was for 11.1 billion gallons (42.0 billion litres) of biofuel to be sold, of which the US Environmental Protection Agency (US EPA 2008b) expected 0.5 billion gallons (1.9 billion litres) to be biodiesel and the remainder ethanol. However, only 1.2 billion litres of biodiesel were actually consumed (EIA (US) 2011k). Assuming that

the remaining biofuel was ethanol, this suggests a mandated volume of 40.8 billion litres in 2009, which is close the actual amount consumed (40.6 billion litres) (EIA (US) 2011k).

Table N.69 **Renewable Fuel Standard targets**[a]

United States, 2011

Biofuel type	*Required volume*		*Percentage of petrol (ethanol) or diesel (biodiesel)*
	billion gallons	billion litres	%
Advanced biofuel[b]	1.35	5.77	0.78
Cellulosic biofuel[c]	0.006	0.023	0.003
Biomass-based diesel[d]	1.2	4.5	0.69
Total biofuels	**13.95**	**52.81**	**8.01**

[a] In practice, the required volumes and percentages are set in 'ethanol-equivalent' volumes (that is, adjusted for energy content relative to ethanol) (US EPA 2010a). [b] 'Advanced' biofuels are defined as biofuel that meets a 50 per cent threshold for life-cycle greenhouse gas emissions reductions (relative to petrol or diesel), and excludes ethanol derived from maize starch. [c] 'Cellulosic' biofuel is defined as biofuel produced from cellulose, hemicellulose or lignin that meets a 60 per cent life-cycle greenhouse gas reduction threshold (relative to petrol or diesel). [d] 'Biomass based diesel' is defined as biodiesel or renewable diesel that is not co-processed with petroleum products, and which meets a 50 per cent emissions-reduction threshold.

Sources: US EPA (2010a, 2010c).

In percentage terms, biofuels were required to comprise 10.21 per cent of all fuels sold (US EPA 2008b). This is greater than the actual proportion consumed in 2009 — 6.3 per cent overall and 7.9 per cent for ethanol — which suggests that fuel suppliers did not meet the mandate in percentage terms (FHWA (US) 2011a).

It is likely that the amount of biodiesel consumed in 2009 was less than expected by US EPA because the 1.9 billion litre requirement for that year was set as part of the RFS2 legislation but regulations had not yet been implemented. Although fuel suppliers were not penalised if they did not meet this target, they were permitted to count the amount supplied in 2009 towards their targets for 2010 (US EPA 2008b). In effect, the RFS provided a guaranteed level of demand for biodiesel in 2009 (although actual consumption fell short of the target, as noted above).

As a result, the Commission assumed that the mandates set under the RFS are 'binding' — that is, the total amount of ethanol and biodiesel that was consumed in the United States in 2009 counted towards the RFS requirements, but did not exceed the mandated level. In other words, the mandate increased domestic demand for biofuels (with a corresponding displacement of petrol and diesel). This is reflected in higher wholesale prices for biofuels than conventional fuels, adjusted for energy content.

Estimating the subsidy equivalent

The subsidy equivalent of the RFS was estimated by calculating the difference in prices received by wholesalers of each fuel type (as a proxy for terminal gate prices), adjusted for the energy content of each fuel. This difference is the production subsidy equivalent (the wholesale price premium for biofuels over conventional fuels). Data for calendar year 2009 were used in the analysis of the RFS as targets are set on a calendar-year basis, rather than for fiscal years.

The Commission assumed that this premium exists because of policy measures that increase the consumption of biofuel. The total amount of biofuel consumed is determined by the RFS, although the price premium that his policy gives to biofuel producers is likely to be further increased by tarrifs that are placed on most imported biofuel to the United States (for example, the tariff on ethanol is 2.5 per cent plus 54 cents per gallon (CBO (US) 2010)).

The subsidy equivalent for each of ethanol and biodiesel was estimated by multiplying the production subsidy equivalent (price premium) by the amount of biofuel consumed. This was done under the assumption that no biofuel would be consumed in the absence of policy measures. In other words, the 'counterfactual' level of consumption is zero, and all consumption is induced by policy measures. (This approach was taken as it was not possible to separate out the effects of individual policy measures on the volume of biofuel consumed.)

Using this approach, the subsidy equivalent in 2009 was estimated to be A$7.3 billion for ethanol and A$472 million for biodiesel, with an total figure of A$7.8 billion (table N.70).

Table N.70 **Subsidy equivalent, Renewable Fuel Standard**
United States, 2009

	Units	*Ethanol*	*Biodiesel*	*Total*
Wholesale price of biofuel[a]	US$/L fuel	0.49	0.78	..
	US$/L petrol equivalent	0.71	0.74	..
Wholesale price of conventional fuel[b]	US$/L fuel	0.47	0.45	..
	US$/L petrol equivalent	0.47	0.40	..
Production subsidy equivalent	**US$/L petrol equivalent**	**0.24**	**0.34**	**..**
Total consumption[c]	ML fuel	40 596	1 198	..
	ML petrol equivalent	28 016	1 256	29 273
Counterfactual consumption	ML petrol equivalent	0	0	0
Policy-induced consumption	ML petrol equivalent	28 016	1 256	29 273
Subsidy equivalent	**US$m (2009)**	**6 671**	**430**	**7 101**
	A$m (2010)	**7 321**	**472**	**7 793**

a The wholesale price of ethanol was calculated as the simple average of weekly US Midwest Average rack prices (charged by wholesalers) over 2009 from the F.O. Licht Interactive Database (accessed 23 April 2011). The wholesale price of diesel is the simple average 'free on board' price in 2009 over four biodiesel types (rapeseed methyl esters from the West Coast, and soybean methyl esters from the East Coast, Gulf Coast and Midwest), also from the F.O. Licht Interactive Database. The proportions of biodiesel purchased at each price were not available; prices ranged from US$0.74–0.83/L. **b** The wholesale prices reported are the average refiner prices (sales for retail) of motor gasoline and 'No. 2 distillate fuels', from the EIA (US) (2010c). **c** Total consumption figures are derived from the EIA (US) (2011k). **..** Not applicable.

Sources: EIA (US) (2010c; 2011k); F.O. Licht Interactive Database (accessed 23 April 2011); Productivity Commission estimates.

State-level fuel standards

In addition to the federal-level RFS, some states have also implemented fuel standards. These include:

- fuel content mandates that require a minimum percentage of biofuel to be blended with petrol or diesel. These mandates vary across states (table N.71)
- low-carbon fuel standards that set the maximum permitted level of life-cycle greenhouse gas emissions from transport fuels (box N.3).

These standards are likely to increase the use of biofuel in states that have implemented them, provided that they 'bind' and fuel suppliers respond by changing the types of fuels that they supply. However, as road transport fuels are easily traded between states it is unlikely that biofuels would attract a significantly higher price premium in one state (with a standard) compared to another (without a standard).

Thus, the Commission has not estimated the subsidy equivalent of state-level renewable fuel standards. As the federal RFS sets the total volume of biofuel

consumed in the United States, the Commission has assumed state-level schemes do not have an additional impact on overall (nation-wide) biofuel consumption. For example, a standard in one state could increase the consumption of ethanol (in that state) but the effect is likely to be offset by lower ethanol consumption in another state (that does not have a fuel content standard).

Table N.71 **State-level fuel content mandates**[a]

United States, 2010

State	*Description*	*Mandated ethanol*	*Ethanol consumption*	*Mandated biodiesel*[b]
		%	%[c]	%
Hawaii	At least 85 per cent of petrol sold must contain at least 10 per cent ethanol.	8.5	9.8	..
Louisiana	Diesel must contain at least 2 per cent biodiesel.	..[d]	5.7	2
Massachusetts	Diesel must contain at least 2 per cent biodiesel (by 1 July 2010).	..	..	2
Minnesota	Petrol must contain at least 10 per cent ethanol, and all diesel sold must contain at least 5 per cent biodiesel.	10.0	10.1	5
Missouri	Petrol must contain at least 10 per cent ethanol. (This mandate does not apply when ethanol-blended petrol is more expensive than straight petrol.)	10.0	7.0	..
New Mexico	Diesel sold to state government agencies must contain at least 5 per cent biodiesel (from 1 July 2010).	..	..	5[e]
Oregon	Petrol must contain at least 10 per cent ethanol. Petrol with an octane rating of 91 or above is exempt.	10.0	8.8	2[f]
Pennsylvania	Diesel must contain at least 2 per cent biodiesel (from May 2010).	..[g]	..	2
Washington	Petrol must contain at least 2 per cent ethanol. Diesel must contain at least 2 per cent biodiesel.	2.0	9.1	2

a Standards have also been proposed or legislated in Iowa and Montana but have not yet been enacted and did not impose requirements on fuel producers in 2010. In addition, a 10 per cent ethanol mandate commenced in Florida in 2011. **b** State-level data on biodiesel consumption were not available. In 2009, the national average was 0.79 per cent of total diesel consumption (EIA (US) 2011k, 2011p). **c** Petrol consumption data from EIA (US) (2011p) include E10. Data for each state are for 2009 as 2010 data were not available. **d** A two per cent ethanol mandate will apply in Louisiana once production capacity in the state reaches 50 million gallons per year. **e** State government fleet only **f** The biodiesel mandate in Oregon increased to 5 per cent on 1 April 2011. **g** A 10 per cent 'cellulosic' ethanol mandate is scheduled to apply in Pennsylvania once production of ethanol in the state reaches 350 million gallons (1325 million litres) per year. **..** Not applicable.

Sources: AFDC (US) (2011); EIA (US) (2011k, 2011p); USDA (2010c).

Box N.3 **Low-carbon fuel standards**

Low-carbon fuel standards set a maximum amount of carbon that can be contained in a given volume of vehicle fuel, or of CO_2-e emitted during the manufacture, transport and use ('life-cycle') of that fuel. Standards are usually expressed in terms of emissions per unit of energy (for example, grams of CO_2-e per megajoule of fuel energy).

The California Low Carbon Fuel Standard was introduced at the beginning of 2011. Similar schemes have also been proposed in several other states, including Oregon, Washington, and several mid-western and north-eastern states (Pew Centre on Global Climate Change 2011a).

Under the Californian scheme, the average emissions intensity of transport fuels must be reduced by 10 percent from 2010 levels by 2020 (CARB (US) 2009). The regulations specify that the emissions-intensity of petrol (and its substitutes, such as ethanol) cannot exceed 95.6 g CO_2-e/MJ. The limit for diesel (and substitutes such as biodiesel) is 94.47 g CO_2-e/MJ.

Fuel suppliers can reduce the emissions intensity of the fuel they sell by blending fuels with biofuels that have lower emissions intensities. The emissions intensity values used to assess each fuel type are based on a study of life-cycle greenhouse gas emissions undertaken by the California Air Resources Board. As with the federal-level Renewable Fuel Standard, fuel producers and importers can create tradable credits.

Sources: CARB (US) (2009); Pew Centre on Global Climate Change (2011a).

Federal Fleet Management Guidance

The Federal Fleet Management Guidance is a set of regulations that cover the vehicle fleet of US federal government departments and agencies. These regulations include targets for the adoption of 'alternative fuel' vehicles (such as those that use E85, B20, LPG or electricity), targets for the installation of 'alternative fuel' pumps, and requirements for government agencies to set emissions-reduction targets (USDE 2011).

Part of the Guidance includes a requirement that agencies with 20 or more vehicles reduce their annual consumption of petroleum-derived products by 2 per cent, relative to a fiscal year 2005 baseline. In addition, agencies must increase their consumption of 'alternative fuels' (including biofuels) by 10 per cent each year until fiscal year 2015 (relative to the same baseline) (USDE 2010).

In fiscal year 2009, total consumption of 'alternative-fuels' by US government agencies was 26 per cent higher than the fiscal year 2005 baseline (table N.72). This was due to a 159 per cent increase in the use of E85, which was offset by a decline in the use of other 'alternative fuels', including biodiesel. Although the increase in

'alternative fuel' consumption is less than the requirement for individual agencies in 2009 (around 46 per cent, calculated as a compound 10 per cent annual increase over four years), it is still substantial.

Assuming that the entire increase in E85 consumption was due to the Guidance, the subsidy equivalent (the estimated government expenditure on E85 that would have been spent on petrol in the absence of the scheme) was approximately A$0.8 million (table N.73).

Table N.72 **Federal fleet fuel consumption**

United States, fiscal years 2005–2009

Fuel type	*FY 2005*	*FY 2009*	*Change FY 2005–2009*	
	ML petrol equivalent	ML petrol equivalent	ML petrol equivalent	%
Petrol	1 137	1 141	4	0.4
Diesel	202	286	84	42
Ethanol (E85)	12	30	18	159
Biodiesel (B20)	30	28	-3	-8
Biodiesel (B100)	0.06	0.02	-0.05	-71
Other 'alternative fuels'[a]	6	3	-3	-53
Total — biofuels	42	58	16	38
Total — all 'alternative fuels'	48	61	13	26

[a] Other 'alternative fuels' include LPG, compressed natural gas, electricity and hydrogen.

Source: GSA (US) (2010).

Table N.73 **Subsidy equivalent, Federal Fleet Management Guidance[a]**

United States, October 2008 – September 2009

	Units	*Value*
Average price for E85	US$/L petrol equivalent	0.66
Average price for petrol	US$/L petrol equivalent	0.62
Premium for E85	US$/L petrol equivalent	0.04
Quantity consumed[b]	ML petrol equivalent	18
Subsidy equivalent	**US$m (2009)**	**0.7**
	A$m (2010)	**0.8**

[a] Average prices for E85 and petrol are from EIA (US) (2011a) and adjusted for energy content. [b] Quantity consumed is equal to the increase in consumption of E85 by US government agencies in fiscal year 2009 minus the amount consumed in fiscal year 2005 (the baseline).

Sources: EIA (US) (2011a); GSA (US) (2010); Productivity Commission estimates.

'Whole-of-market' analysis

Estimating the total subsidy equivalent

Adding together the estimated subsidy equivalents of the policies analysed above, the 'whole-of-market' total subsidy equivalent is A$16.1 billion for ethanol and A$1.4 billion for biodiesel, which totals A$17.5 billion for biofuel policies in the United States (table N.74).

Table N.74 **Total subsidy equivalent**

United States, October 2008 – September 2009

Policy	*Level of government*	*Subsidy equivalent*			
		Ethanol	*Biodiesel*	*Total*	
		US$m (2009)	US$m (2009)	US$m (2009)	A$m (2010)
Alcohol and Biodiesel Fuel Credits	National	5 210	840	6 050	6 640
Bioenergy Program for Advanced Biofuels	National	7.3	6.5	14	15
State-level excise concessions for ethanol	Sub-national	2 760	..	2 760	3 029
Renewable Fuel Standard[a]	National	6 671	430	7 101	7 793
Federal Fleet Management Guidance	National	0.7	..	0.7	0.8
Total	**..**	**14 649**	**1 276**	**15 925**	**17 477**

[a] The central estimate of the subsidy equivalent is reported for the Renewable Fuel Standard. This includes the impact of import tariffs. **..** Not applicable.

Source: Productivity Commission estimates.

Estimating abatement

Using the 'whole-of-market' approach, total abatement was estimated to be 23 Mt CO_2-e for ethanol and 3 Mt CO_2-e for biodiesel, which totals 26 Mt CO_2-e (table N.75). This was calculated by multiplying the volume of each biofuel consumed by its average abatement factor.

Table N.75 **Total abatement**
United States, 2009

	Units	*Ethanol*	*Biodiesel*	*Total*
Policy-induced consumption	ML fuel	40 596	1 198	..
	ML petrol equivalent	28 016	1 256	29 273
Average abatement factor	g CO_2-e/L petrol equivalent	832	2 318	..
Abatement	**Mt CO_2-e**	**23**	**3**	**26**

.. Not applicable.

Source: Productivity Commission estimates.

The average implicit abatement subsidy

The average implicit abatement subsidy is A$689/t CO_2-e for ethanol, A$481/t CO_2-e for biodiesel and A$666/t CO_2-e overall (table N.76).

Table N.76 **Average implicit abatement subsidy**
United States, 2009

	Units	*Ethanol*	*Biodiesel*	*Total*
Total subsidy equivalent	US$m (2009)	14 649	1 276	15 925
	A$m (2010)	16 076	1 401	17 477
Abatement	Mt CO_2-e	23	3	26
Implicit abatement subsidy	**US$/t CO_2-e**	**628**	**438**	**607**
	A$/t CO_2-e	**689**	**481**	**666**

Source: Productivity Commission estimates.

Sensitivity analysis

Sensitivity analysis was used to show the effect of varying the counterfactual level of consumption — that is, the volume of biofuel that would have been consumed without policy support — and the effect of using different wholesale price data for ethanol and biodiesel in the analysis of the RFS. The results are compared to the estimates presented above, which are referred to as the 'central estimates'.

Altering the counterfactual level of consumption

Ethanol is sometimes added to petrol as an oxygenate in the United States. The resulting blend — a form of 'reformulated gasoline' — has chemical properties that reduce emissions of particulates and harmful chemicals. Reformulated gasoline is mandated in several areas of the United States where there are high levels of air

pollution (US EPA 2008a). In some of these, cheaper fuel additives (such as methyl tertiary butyl ether) have been banned, meaning that ethanol is the main chemical used for oxygenation.

Ethanol used for this purpose does not directly compete with petrol. As a result, there may be some level of ethanol consumed in the absence of policy measures, in order to meet air quality regulations. The US EPA (2007a) estimated that approximately 2.6 per cent of total petrol consumption in 2012 would consist of ethanol that is used to comply with these regulations. In 2009, a total of 513 billion litres of petrol (including ethanol) were consumed (EIA (US) 2011p). Assuming that 2.6 per cent of this was used as an oxygenate, then the counterfactual level of consumption would be 13.3 ML (equal to 33 per cent of actual ethanol consumption) and the volume attributable to policy measures would be reduced to 27.3 ML (in calendar year 2009).

This lower level of policy-induced consumption was used to adjust the estimates for the two policies that provided the largest subsidy equivalents for ethanol in calendar year 2009: the RFS and the Alcohol Fuel Credits.

- The production subsidy equivalent for the RFS (the price premium) was multiplied by 27.3 ML to adjust the subsidy equivalent of the RFS.
- The production subsidy equivalent for the Alcohol Fuel Credits (US$0.12/L) was multiplied by a slightly lower figure of 25.9 ML to adjust the subsidy equivalent of that policy. (This lower volume applies to fiscal year 2009 as data on these tax credits were only available over that time period.)
- In addition, the 'whole-of-market' estimate of abatement for ethanol was adjusted by multiplying 27.3 ML by the average abatement factor of ethanol.

The subsidy equivalents of other policies were not adjusted in this scenario as it is unlikely that ethanol used only to oxygenate petrol (and which would be used in the counterfactual) would benefit from these policies. This is because the Bioenergy Program excludes maize-derived ethanol (which is generally the cheapest and most widely used feedstock in the United States), and the Federal Fleet Management Guidance and state-level excise exemptions are targeted at particular ethanol blends (E85 and E10 respectively) that each contain more ethanol than is usually required to oxygenate petrol to meet air quality regulations. In other words, these other policies are expected to target ethanol consumption that is induced solely by the set of all policy measures.

The above adjustments reduce the estimates of the total subsidy equivalent and abatement, and increase the estimate of the implicit abatement subsidy to A$724/t CO_2-e for ethanol and A$672/t CO_2-e overall (table N.77).

Using different wholesale price data

Several wholesale prices were available for ethanol and biodiesel over 2009. In addition to the figures used in the central analysis, values reported by the Center for Agricultural and Rural Development (CARD) and Energy Information Administration (EIA) were also used.

- CARD have calculated wholesale prices for both ethanol and biodiesel, based on a set of assumptions about input prices and other operating costs (CARD 2011) — the simple average values over 2009 are US$0.45/L of ethanol (lower than the price used for the central estimates) and US$0.81/L of biodiesel (higher).
- The EIA has reported an average price of US$2.18/gallon (US$0.58/L) received by biodiesel producers in 2009, based on survey data (EIA (US) 2010c) (lower than the price used for the central estimates).

Using these prices alters the total subsidy equivalent and implicit abatement subsidy for each fuel type (table N.77). Using CARD wholesale prices in the analysis results in an implicit abatement subsidy that is lower than the central estimate for ethanol (A$617/t CO_2-e), but slightly higher for biodiesel (A$494/t CO_2-e). By contrast, the EIA biodiesel price suggests an implicit abatement subsidy that is significantly lower (A$389/t CO_2-e) than the central estimate.

Table N.77 **Sensitivity analysis**

United States, 2009

Scenario	*Total subsidy equivalent*		*Abatement*	*Implicit abatement subsidy*	
	US$m (2009)	A$m (2010)	Mt CO_2-e	US$/t CO_2.e	A$/t CO_2-e
Ethanol					
'Central'	14 649	16 076	23	628	689
Non-zero counterfactual consumption	10 330	11 337	16	660	724
CARD wholesale price	13 115	14 394	23	562	617
Biodiesel					
'Central'	1 276	1 401	3	438	481
CARD wholesale price	1 311	1 439	3	450	494
EIA wholesale price	1 033	1 133	3	355	389
Total					
'Central'	15 925	17 477	26	607	666
Non-zero counterfactual consumption	11 363	12 470	19	612	672
CARD wholesale prices	14 427	15 833	26	550	604
EIA wholesale price	15 682	17 210	26	598	656

Source: Productivity Commission estimates.

Annex

Average petrol and diesel prices were estimated using the fuel price regulation notices issued by the NDRC for 2009. These notices specify the retail price of petrol (grade 90 gasoline) and diesel in each province or town. The prices announced in the NDRC price notices reflect the maximum retail price that can be charged and actual prices could be lower during this period. Consequently, our average diesel price estimated could overstate the actual prices during this period.

Average diesel price estimates

As volume of diesel consumed by province was not available, an average national price was estimated using registration of new vehicles by province as a weight (as a proxy of fuel use). The estimated weighted average price for diesel in 2009 was ¥5.2/L (¥6557/t) (table M.5).

Average petrol price estimates

Average petrol prices (‘grade 90’ petrol) were estimated for each province where ethanol is consumed. The average figure for each province is a weighted average by the time period over which these standard prices were in place

Table M.78 **NDRC regulated retail diesel price by province and city**

China, December 2008 to December 2009, A$/L

	Date of price announcements								
Province/ city	*18 Dec 2008*	*14 Jan 2009*	*24 Mar*	*31 May*	*29 Jun*	*28 Jul*	*1 Sep*	*29 Sep*	*9 Nov*
Beijing	4.93	4.80	4.94	5.26	5.73	5.56	5.80	5.65	6.03
Tianjin	4.52	4.40	4.54	4.85	5.33	5.15	5.39	5.24	5.62
Hebei	4.52	4.40	4.54	4.85	5.33	5.15	5.39	5.24	5.62
Shanxi	4.57	4.44	4.58	4.90	5.37	5.20	5.34	5.28	5.66
Liaoning	4.52	4.40	4.54	4.85	5.33	5.15	5.39	5.24	5.62
Jilin	4.52	4.40	4.54	4.85	5.33	5.15	5.39	5.24	5.62
Heilongjiang	4.52	4.40	4.54	4.86	5.33	5.15	5.39	5.24	5.62
Shanghai	4.53	4.40	4.54	4.90	5.33	5.16	5.39	5.24	5.62
Shandong	4.53	4.40	4.55	4.86	5.34	5.16	5.40	5.25	5.63
Hubei	4.54	4.42	4.56	4.87	5.35	5.17	5.41	5.26	5.64
Hunan	4.59	4.46	4.61	4.92	5.39	5.22	5.46	5.31	5.69
Henan	4.54	4.41	4.55	4.87	5.34	5.17	5.41	5.26	5.64
Heinan	4.63	4.50	4.64	4.96	5.43	5.26	5.50	5.35	5.73
Guangdong	4.58	4.45	4.59	4.91	5.38	5.21	5.45	5.30	5.68
Guangxi	4.63	4.50	4.64	4.96	5.43	5.26	5.50	5.35	5.73
Ningxia	4.52	4.40	4.54	4.85	5.33	5.15	5.39	5.24	5.62
Gansu	4.54	4.41	4.55	4.87	5.34	5.17	5.41	5.26	5.64
Xinjiang	4.44	4.31	4.45	4.77	5.24	5.07	5.31	5.16	5.54
Inner Mongolia	4.53	4.41	4.55	4.87	5.34	5.17	5.40	5.25	5.63
Jiangsu	4.53	4.40	4.54	4.86	5.34	5.19	5.42	5.27	5.65
Zhejiang	4.57	4.44	4.58	4.90	5.37	5.20	5.43	5.28	5.66
Anhui	4.54	4.41	4.55	4.87	5.34	5.17	5.41	5.26	5.66
Fujian	4.56	4.43	4.55	4.89	5.36	5.19	5.43	5.28	5.66
Jiangxi	4.54	4.41	4.55	4.87	0.53	5.17	5.41	5.26	5.64
Sichuan	4.71	4.58	4.72	5.04	5.51	5.34	5.58	5.43	5.81
Chongqing	4.68	4.55	4.70	5.01	5.49	5.31	5.55	5.40	5.79
Guiyang	4.65	4.52	4.66	4.98	5.45	5.28	5.52	5.37	5.75
Kunming	4.67	4.55	4.69	5.00	5.48	5.30	5.54	5.39	5.77
Xian	4.53	4.40	4.55	4.86	5.34	5.16	5.40	5.25	5.63
Xining	4.55	4.42	4.56	4.88	5.35	5.18	5.41	5.26	5.64

a The standard diesel price is required to be applied across the entire province. However, in some periods, some provinces do not have a unique price and instead the price is listed for the capital city.

Source: NDRC 2011.

Table M.79 **NDRC regulated retail petrol (grade 90) price by province and city**

China, December 2008 to December 2009, A$/L

	Date of price announcements									
Province/ city	*18 Dec 2008*	*14 Jan 2009*	*25 Mar*	*31 May*	*29 Jun*	*28 Jul*	*1 Sep*	*29 Sep*	*9 Nov*	*Average 2009*
Hebei	4.69	4.59	4.80	5.10	5.54	5.38	5.60	5.46	5.81	5.17
Liaoning	4.69	4.59	4.80	5.10	5.54	5.38	5.60	5.46	5.81	5.17
Jilin	4.69	4.59	4.80	5.10	5.54	5.38	5.60	5.46	5.81	5.17
Heilongjiang	4.69	4.59	4.80	5.10	5.54	5.38	5.60	5.46	5.81	5.17
Jiangsu (Nanjing)[a]	4.70	4.60	4.81	5.11	5.58	5.42	5.64	5.50	5.85	5.20
Shandong	4.70	4.59	4.81	5.10	5.55	5.38	5.61	5.47	5.82	5.18
Hubei	4.71	4.60	4.82	5.11	5.56	5.40	5.62	5.48	5.83	5.19
Henan	4.70	4.60	4.81	5.11	5.56	5.39	5.65	5.47	5.83	5.19
Guangxi	4.80	4.69	4.91	5.20	5.65	5.48	5.71	5.57	5.92	5.28
Anhhui (Hefei)[a]	4.70	4.60	4.81	5.11	5.56	5.39	5.61	5.47	5.85	5.19

a The standard petrol price is required to be applied across the entire province. However, in some periods, some provinces do not have a unique price and instead the price is listed for the capital city.

Source: NDRC 2011.

O Demand-side analysis for road transport

This appendix sets out the detailed calculations, assumptions and data sources that the Commission used to estimate the demand-side abatement and consumption costs for road transport in the study countries. The analysis covers fuel taxes and biofuel policies.

O.1 Data and assumptions

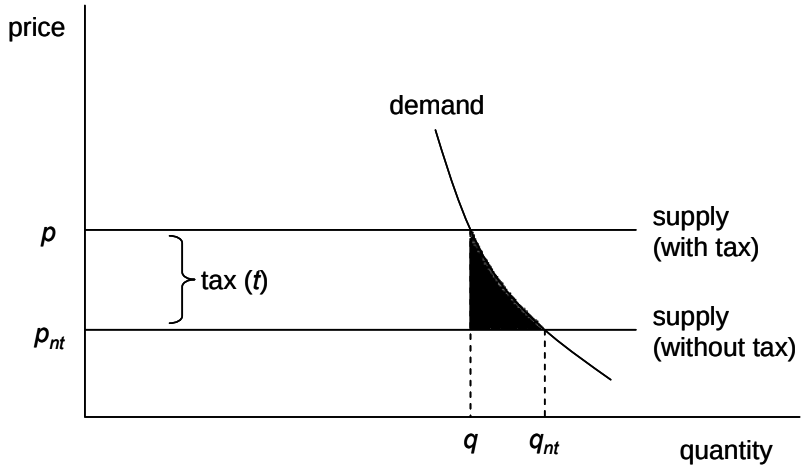
The Commission estimated the consumption cost, abatement, and average consumption cost (per tonne of CO_2-e) of road transport fuel policies in each country. The broad approach is outlined in chapter 3 and the specific application to fuel taxes is set out in box O.1.

For fuel taxes, this includes estimates of the three major types of fuels used for road transport — petrol, diesel and liquefied petroleum gas (LPG) — as well as an aggregate for each country (LPG was not included where it is not taxed). Only volumetric (per litre) taxes were included in the analysis, where levied specifically on fuels. Other taxes were not analysed, including broadly based sales or consumption taxes, and taxes that are not directly levied on fuels (such as vehicle taxes, road tolls or distance charges).

Emissions trading schemes (ETSs) that cover transport fuels were included in the analysis, as these are often levied on fuel suppliers in a similar way to fuel excise. Currently, the only ETS that covers transport fuels is in New Zealand. However, some taxes that may meet the above criteria were not included in the transport sector analysis due to insufficient data, such as the system of fuel price controls in China and the Petroleum and Coal Tax in Japan.

In the case of biofuels, the impact of policies on fuel prices was estimated, followed by demand-side abatement and consumption costs. This analysis is based on the analysis of biofuel policies in appendix N (for the supply side). Some policies that encourage the substitution of biofuels for conventional fuels (petrol or diesel) may lead to higher fuel prices.

Box O.1 **Quantifying demand-side costs and abatement**



The Commission estimated the consumption costs of fuel taxes and biofuel policies on the demand side. These costs are a measure of the value to consumers of forgone fuel consumption, minus the value of other goods and services that can be purchased instead (chapter 3). This is shown as the shaded area in the figure. For example, as a fuel tax (t) raises the price of fuel (from the price with no tax, p_{nt}, to p, with the tax), consumers reduce the amount of fuel they purchase (from q_{nt} to q), assuming a perfectly elastic fuel supply curve.

A constant-elasticity demand curve was used to estimate consumption costs. This takes the mathematical form $q = Cp^{\varepsilon}$, where q is the quantity of fuel consumed, p is the fuel price, ε is the own-price elasticity of demand, and C is a constant (a number that indicates the position of the demand curve for a given country).

This type of demand curve implies that the own-price elasticity of demand — the responsiveness to small changes in the price — is constant over all volumes of fuel (that is, over the entire demand curve). A different approach was used to estimate the demand-side impacts of policies in the electricity sector, which considered price changes of a much smaller magnitude than fuel taxes (appendix L). However, a constant-elasticity demand curve was used for road transport as it is presumed to provide a better indication of the responsiveness of fuel demand to the significant price increases that result from fuel taxes.

Using the constant-elasticity demand curve, the reduction in fuel consumption (Δq) is:

$$\Delta q = q\left(1 - \left(\frac{p-t}{p}\right)^{\varepsilon}\right)$$

and demand-side abatement can be expressed as $A = (-\Delta q)\beta$, where β is the life-cycle emissions intensity of the fuel. Consumption costs were calculated as: $\int_{p-t}^{p} Cp^{\varepsilon}\,\mathrm{d}p - qt$

and the average consumption cost (per tonne of CO_2-e abated) was calculated by dividing estimated consumption costs by estimated abatement.

Consumption costs and abatement were only calculated for biofuel policies where the cost of a policy was likely to be passed through to consumers in the form of higher fuel prices. In the majority of cases, costs are paid by taxpayers, either as government expenditure or forgone revenue (and thus are not expected to lead to higher fuel prices).

Thus, the analysis only covers three countries — Germany, the United Kingdom and the United States — that have 'binding' fuel content mandates. These mandates set requirements for the amount of biofuel that must be blended into transport fuels. Assuming that the cost of meeting these mandates is passed through to consumers through higher fuel prices, the amount of fuel consumed — and hence emissions — is expected to be lower.

Illustrative estimates of the increase in fuel prices are also provided for each country.

Assumptions used to analyse fuel taxes

Many assumptions were required in order to calculate the estimates of the cost and abatement from fuel taxes in each country. These assumptions reflect both the availability of data and the extent to which costs and abatement can be attributed to fuel taxes. As discussed in chapter 5, to the extent that fuel taxes are used to meet objectives other than emissions reductions (or raise revenue for particular purposes), the cost of taxes may not be fully attributable to any estimated abatement. Thus, the estimates provide only an illustration of the cost and abatement that could be induced by fuel taxes on the demand side, in the absence of offsetting benefits.

The key assumptions are:

- cost and abatement are estimated by comparing observed fuel prices and quantities in each country with a counterfactual scenario in which fuel tax had never been imposed
  - the analysis does not incorporate any offsetting benefits that may arise from the use of fuel taxes to meet other objectives (such as reducing congestion or urban air pollution)
  - the counterfactual does not include other policies that may have been in place to meet the objectives that are currently met by fuel taxes (for example, to raise general revenue)
- the estimates of abatement do not take into account the potential offsetting effects on emissions that could arise from consumers switching between transport modes (for example, abatement that arises from lower vehicle use may

be offset by higher emissions from rail, to the extent that demand for rail is increased).

Assumptions used to analyse biofuel policies

A number of assumptions also needed to be made to provide illustrative estimates of consumption costs and abatement for biofuel policies. The following assumptions were made, in addition to the assumptions used for fuel taxes.

- The subsidy equivalent of fuel content mandates is passed on in full to all fuel users, in the form of a price increase.
  - In addition, this price increase is spread evenly across all fuel consumed.
- All petrol and diesel used for road transport is subject to the fuel content mandate.
- The life-cycle emissions intensity of blended fuel is the average emissions intensity value of the biofuel and the conventional fuel it displaces (weighted by the volume of each that is consumed).

These assumptions mean that the results are likely to be over-estimates of the actual price uplift and average consumption costs.

Elasticity values

Key inputs to the demand-side analysis were estimates of the own-price elasticity of fuel demand, which measure the responsiveness of consumers to higher fuel prices (box O.2). The values used are based on a review of the literature (section O.11).

Given the large variation in estimates of fuel demand elasticities in the literature, it is difficult to identify a single value for a given country with confidence. As a result, the Commission has used a range of elasticity values for analysis of fuel taxes based on estimates of long-term elasticities in the literature. This range is -0.25 (the ‘low’ value) to -0.75 (the ‘high’ value).

Long-term estimates have been used, as fuel taxes have been in place for a considerable period of time in most study countries. It is likely that consumers have responded to these taxes by changing their transport choices over this period.

The same elasticity values have generally been used for each country and each fuel type. Although there is some variation in the specific values for any one country or fuel type, the range used here is expected to capture likely responses.

Box O.2 **Responses to higher fuel prices**

Higher fuel prices — whether due to fuel taxes or other factors, such as changes in world oil prices — reduce the demand for fuel by giving consumers an incentive to use less fuel.

Consumers can respond in a number of ways. For example, in the short term higher fuel prices could change driving behaviours (such as driving at different times of the day or reducing the number of trips made). Over the longer term, consumers could purchase more fuel-efficient vehicles or substitute towards other modes of transport (such as buses, trains or bicycles). In addition, freight companies could substitute away from road transport towards rail or air transport.

The extent to which consumers respond to higher fuel prices can be influenced by many factors. For example, there may be greater substitution towards other modes of transport in more densely populated cities or countries, where public transport is more widely available. Other kinds of taxes — including vehicle taxes, road tolls and congestion charges — can also affect how consumers respond to higher fuel prices.

The overall responsiveness of consumers to higher fuel prices can be estimated using the own-price elasticity of fuel demand. This is a measure of the percentage change in the quantity of fuel demand in response to a small change in the fuel price. Demand for fuel is generally inelastic — a one per cent increase in the fuel price leads to a smaller percentage change in the quantity demanded. For example, an elasticity value of -0.5 indicates that a 1 per cent rise in the fuel price would reduce demand by 0.5 per cent.

However, measuring the overall price elasticity of fuel demand is complex. This typically requires data on fuel prices, fuel demand (consumption) and other factors such as income, vehicle ownership rates and the fuel efficiency of vehicles — which can also affect fuel demand.

Consequently, there is wide variation across studies, depending on the data sources and methodology used, as well as the country and time period considered (section O.11). Despite this variation, most studies find that consumers are more responsive to fuel prices in the longer term (that is, the elasticity value becomes larger, in absolute terms) than in the shorter term (where the elasticity value is closer to zero).

However, a different range was used for policies that have been in place for a shorter period of time. For example, the analysis of the proposed LPG excise in Australia uses elasticity values of -0.1 to -0.25, based on short-term estimates in the literature (section O.11).

The demand-side analysis of biofuel policies also used short-term estimates, since the biofuel mandates analysed have not been in place for as long as fuel taxes in these countries (table O.1). A range of -0.1 to -0.25 was used for the United States, and a range of -0.25 to -0.75 for Germany and the United Kingdom (as there is evidence in the literature that short-term elasticities in Europe are likely to be in this

range, with consumers being more responsive to changes in fuel prices than those in the United States).

Table O.1 **Short-term fuel demand elasticity values**

Country	*Year mandate implemented*	*Elasticity values*	
		low	high
Germany	2007	-0.25	-0.75
United Kingdom	2008	-0.25	-0.75
United States	2008	-0.1	-0.25

Data

Fuel taxes

The analysis of fuel taxes required the following 'input' data for each country and fuel type (petrol, diesel and LPG), as set out in box O.1.

- The tax rate (per litre).
  - This includes fuel excise as well as other volumetric taxes levied specifically on transport fuels.
- The quantity of fuel that is taxed and used for road transport.
  - Where possible, this was estimated by dividing total tax revenue by the tax rate.
  - Where revenue data were not available, fuel consumption data were used (in many cases these data are likely to be less accurate, as they often include fuel that is used outside of road transport or non-taxed uses of fuel).
- The average retail price (per litre).
  - An average was used where prices were only available for separate categories of fuel (such as regular and premium unleaded petrol), weighted by the share of each fuel type.
- Emissions of CO_2-e per litre of fuel, measured on a life-cycle basis (the values used for each country are set out in appendix M).

These data were obtained — or calculated using other data — on an annual basis in the local currency of each country. Data were collected for the most recent year available, with the same year used for all data for each country. Where key data varied over the year or across a country, the analysis was conducted for separate time periods or sub-national regions, and the results added together.

All quantity (fuel consumption) values are expressed in 'litres of petrol equivalent' to enable comparisons across different fuel types. This was done by using the energy content of each fuel to express amounts in an equivalent volume of petrol that contains the same amount of energy. Conversion rates differ slightly across countries and are set out in appendix M.

Further assumptions, data sources and detailed calculations are set out in the country sections below.

Biofuel policies

Consumption costs and abatement were calculated by first estimating the increase in fuel prices. This was done by dividing the central estimate of the subsidy equivalent (estimated in appendix N) by the volume of fuel that is consumed. The calculations and results are set out in section O.10.

Exchange rates

Results for each country were calculated in local currency, converted to 2010 values (using GDP deflators), and then converted to Australian dollars. This was done using the deflators and exchange rates listed in table O.2.

Table O.2 **Exchange rates to 2010 Australian dollars**

Country	*Currency*	*Data year used for analysis*	*Deflator to 2010*[a]	*Exchange rate per A$*[b]
Australia	Australian dollar (A$)	July 2009 – June 2010	1.03	1
China	Chinese yuan (CNY)	January – December 2010	1.00	6.2167
Germany	euro (€)	January – December 2009	1.01	0.6979
Japan	Japanese yen (¥)	April 2009 – March 2010	0.98	80.12
New Zealand	New Zealand dollar (NZ$)	January – December 2010	1.00	1.2778
South Korea	Korean won (KRW)	January – December 2009	1.03	1065.08
United Kingdom	pound sterling (£)	January – December 2010	1.00	0.5963
United States	United States dollar (US$)	January – December 2009	1.01	0.9199

a Deflators to 2010 values (in local currency) are based on the GDP chain price index from the RBA (2011) for Australia, and from the IMF (2011) for all other countries (using the whole calendar year that covers most of the data analysis period). **b** Annual average exchange rates for 2010 are from the RBA (2011).

Sources: IMF (2011); RBA (2011).

O.2 Australia

Australia levies excise on petrol, diesel and most biofuels at the rate of 38.143 cents per litre. There is currently no excise on gaseous fuels (including LPG), although the government has recently introduced legislation to parliament that will impose excise on these fuels from 1 December 2011 (Treasury 2011; Shorten 2011).

Most businesses are eligible to receive a tax credit through the Fuel Tax Credit Scheme that effectively offsets the amount of excise paid. This scheme provides a tax credit for the use of certain vehicles for business purposes (vehicles with a gross weight of 4.5 tonnes or more and diesel vehicles acquired before 1 July 2006). The tax credit was provided at the rate of 16.443 cents per litre over 2009-10 (ATO 2010b), which effectively reduces the excise paid by this amount.

Estimating consumption costs and abatement

Consumption costs and abatement for fuel taxes in Australia were estimated for the 2009-10 financial year (July 2009 – June 2010). Average retail prices, excise rates, excise revenues and the reported level of taxed consumption for 2009-10 are provided in table O.3.

Table O.3 **Fuel taxes**
Australia, July 2009 – June 2010

Fuel type	*Average retail price*	*Excise rate*	*Gross excise revenue*	*Reported level of taxed consumption*
	A$/L	A$/L	A$m (2009-10)	ML
Petrol	1.242[a]	0.38143	6 285	16 477
Diesel	1.245	0.38143	6 862	17 991[b]
LPG	0.593	..	..	..

a Average price of regular unleaded petrol (ACCC 2010). **b** The level of taxed consumption used in the analysis is lower (4898 ML), to adjust for the Fuel Tax Credits Scheme. **..** Not applicable.

Sources: ACCC (2010); ATO (2011a; 2011b); Productivity Commission estimates.

Fuel Tax Credits Scheme

The Fuel Tax Credits Scheme effectively reduces the amount of excise paid on some fuels. The total value of tax credits under this scheme was A$4994 million in 2009-10 (ATO 2011b). However, the Australian Taxation Office does not collect data on the amount of credits provided to each fuel type, the volume of fuel for which credits are claimed, or the amount of fuel that is used for road transport (Treasury, pers. comm., 15 April 2011). The Commission thus assumed that all tax

credits applied to diesel vehicles used for road transport as most vehicles over 4.5 tonnes are likely to be diesel vehicles.[1]

As a result, the level of taxed consumption of diesel used in the analysis has been reduced by offsetting the amount of fuel tax credits from diesel excise revenues. The estimated proportion of diesel use that receives the tax credit was calculated by dividing the value of tax credits by gross excise revenues (A$4994 million divided by A$6862 million, or 73 per cent). This was then multiplied by the taxed volume of fuel (17 991 ML, calculated by dividing gross excise revenues by the excise rate) to give a figure of 13 093 ML. Subtracting this from the total volume gives a figure of 4898 ML, which has been used in the analysis.

Proposed excise on LPG

As there is currently no excise on LPG, the main analysis is for petrol and diesel only. However, the Government has recently introduced legislation to Parliament that will impose excise on LPG and other 'alternative' fuels (Treasury 2011; Shorten 2011).

The Commission has calculated illustrative estimates of the consumption costs and abatement for this excise. As the rate is scheduled to be raised over time, estimates are provided for the initial tax rate (2.5 cents per litre, from 1 December 2011 to 30 June 2012) and the 'final tax rate' (12.5 cents per litre, from 1 July 2015) (Treasury 2011).

This analysis involved several assumptions:

- average retail LPG prices remain the same as in 2009-10
- annual LPG consumption for road transport remains at its current level of 2083 ML (Department of Resources, Energy and Tourism 2010)
  - estimates for the initial tax rate use seven-twelfths of this figure (1215 ML) as the rate is to apply only over a seven month period
  - estimates for the final tax rate are for an entire year
- the price level in Australia remains at the 2010 level (no inflation).

In addition, a lower range of elasticity values (-0.1 to -0.25) was used than in the analysis of petrol and diesel excise. These lower values are short-term values that

[1] The reported volume of fuel subject to excise (ATO 2011b) does not distinguish between on-road and off-road uses of fuel. For consistency, it has been assumed that all taxed fuel — and all fuel for which tax credits are received — is used for road transport.

are more likely to reflect the initial responses by consumers to the LPG excise, as set out in the introduction to this appendix.

Results

Estimated consumption costs and abatement for fuel taxes in Australia (petrol and diesel) are presented in table O.4. Average consumption costs (per tonne of abatement) are presented in table O.5.

Table O.4 **Consumption costs and abatement**
Australia, July 2009 – June 2010

Elasticity	*Reduction in fuel consumption*		*Consumption cost*	*Abatement*
	ML	ML petrol equivalent	A$m (2010)	Mt CO_2-e
Petrol				
Low	1 583	1 583	287	5
High	5 219	5 219	917	16
Diesel				
Low	469	529	85	2
High	1 546	1 745	272	5

Source: Productivity Commission estimates.

Table O.5 **Average consumption costs**
Australia, July 2009 – June 2010

Elasticity	*Reduction in fuel consumption*	*Consumption cost*	*Abatement*	*Average consumption cost*
	ML petrol equivalent	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Low	2 112	373	6	59
High	6 964	1 189	21	57

Source: Productivity Commission estimates.

LPG excise

Estimated consumption costs and abatement for the proposed LPG excise are presented in table O.6 for two scenarios: a rate of 2.5 cents per litre (over a seven month period) and a rate of 12.5 cents per litre (over a one year period).

Table O.6 **Average consumption costs, LPG excise**

Australia, data for July 2009 – June 2010

Elasticity	*Reduction in fuel consumption*		*Consumption cost*	*Abatement*	*Average consumption cost*
	ML	ML petrol equivalent	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
2.5 cents per litre					
Low	5	4	0.07	0.01	6
High	13	10	0.16	0.03	6
12.5 cents per litre					
Low	50	37	3	0.10	30
High	127	95	8	0.25	30

Source: Productivity Commission estimates.

O.3 China

China taxes petrol and diesel at the national level through the 'Consumption Tax' (there is no volumetric tax on LPG used for road transport). The rates are CNY 1.0/L of petrol and CNY 0.8/L of diesel (ERI (China) pers. comm., 20 April 2011). There are also retail price controls in China that could offset the effects of fuel taxes at times. However, the impact of these price controls is difficult to quantify (box O.3).

Estimating consumption costs and abatement

Consumption costs and abatement for fuel taxes on petrol and diesel in China were estimated for the 2010 calendar year. Data on fuel taxes, average retail prices and the volume of taxed fuel used for road transport were provided to the Commission by the Energy Research Institute (ERI).

Average retail prices, tax rates and the volume of taxed consumption are provided in table O.7. The price of petrol grade 93 (that is, petrol with an octane number of 93) was used in the analysis as this is the most widely used grade in China (ERI (China) pers. comm., 26 April 2011).

Box O.3 **Fuel price controls in China**

China has a system of fuel price controls that regulates the prices of refined oil products, such as petrol and diesel. Fuel prices are fixed and adjusted when the average price of crude oil on international markets undergoes a sustained change (defined as an increase or decrease that exceeds 4 per cent and lasts for 22 consecutive days).

These price controls could offset — or increase — the effect of excise on fuel consumption. This could effectively subsidise or tax domestic consumption. If the price controls act like a tax because crude oil prices have fallen but this has not yet been reflected in domestic fuel prices, there could be some abatement. However, if the price controls act like a subsidy, there could be an increase in emissions (relative to a counterfactual scenario where there are no price controls).

The impact of price controls on retail prices could be assessed using a 'price-gap' approach. For example, the International Energy Agency (IEA) has estimated fossil fuel subsidies by comparing the average consumer price of a fuel with the corresponding 'reference' price. This reference price is an estimate of what the domestic fuel price would have been without subsidies or regulations. It is calculated using the prevailing import parity price for crude oil, adjusted for differences in fuel quality and the costs of freight, insurance, distribution, marketing and value-added taxes (IEA 2010n).

However, the IEA did not analyse price controls for road transport fuels in China, as it did not consider these to have a significant effect on fuel prices.

Source: IEA (2010n).

Table O.7 **Fuel taxes**

China, 2009

Fuel type	*Average retail price*[a]	*Tax rate*	*Level of taxed consumption*
	CNY/L	CNY/L	ML
Petrol	..	..	81 554[b]
Grade 90	6.0	1.0	na
Grade 93	6.5	1.0	na
Grade 97	7.0	1.0	na
Diesel	6.3	0.8	82 931

a Price data are for 2010 as national average prices for 2009 were not available. **b** Total taxed consumption of all petrol grades. **na** Not available. **..** Not applicable.

Source: ERI (China) (pers. comm., 20 April 2011).

Results

Estimated consumption costs and abatement for fuel taxes in China are presented in table O.8. Average consumption costs (per tonne of abatement) are presented in table O.9.

Table O.8 **Consumption costs and abatement**
China, 2010

Elasticity	*Reduction in fuel consumption*		*Consumption cost*		*Abatement*
	ML	ML petrol equivalent	CNY m (2010)	A$m (2010)	Mt CO_2-e
Petrol					
Low	3 478	3 478	1 679	270	10–11
High	10 886	10 886	5 178	833	32–36
Diesel					
Low	2 866	3 259	1 114	179	10–11
High	8 898	10 118	3 418	550	30–33

Source: Productivity Commission estimates.

Table O.9 **Average consumption costs**
China, 2010

Elasticity	*Reduction in fuel consumption*	*Consumption cost*		*Abatement*	*Average consumption cost*
	ML petrol equivalent	CNY m (2010)	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Low	6 737	2 792	449	20 – 22	20 – 23
High	21 003	8 596	1 383	62 – 68	20 – 22

Source: Productivity Commission estimates.

O.4 Germany

Excise is levied on road transport fuels at the federal level in Germany. Rates vary by the type of fuel and its sulphur content, and have been at current levels since July 2006 (table O.10).

Table O.10 **Fuel excise rates**
Germany, 2011

Fuel type	*Excise rate*
	€/L
Unleaded petrol with sulphur content of 10 milligrams per kilogram (mg/kg) or less	0.6545
Unleaded petrol with sulphur content greater than 10 mg/kg	0.6698
Diesel with sulphur content of 10 mg/kg or less	0.4704
Diesel with sulphur content greater than 10 mg/kg	0.4857
LPG	0.1803[a]
Liquefied natural gas	0.4090[a]
Other liquid gases	0.1217[a]

a Rates are per kilogram.

Source: Federal Customs Administration (Germany) (2011).

Estimating consumption costs and abatement

Consumption costs and abatement for fuel taxes in Germany were estimated for the 2009 calendar year. Average retail prices, excise rates and consumption volumes for 2009 are provided in table O.11. Data for the volume of fuels consumed for road transport were used, as revenue data include biofuel blended with petrol and diesel.

Table O.11 **Fuel taxes**
Germany, 2009

Fuel type	*Average retail price*	*Excise rate*	*Fuel consumption*
	€/L	€/L	ML
Petrol[a]	1.28	0.6545	25 562
Diesel[a]	1.09	0.4704	31 174
LPG	0.59[b]	0.0992	942

a Excise rates on petrol and diesel diesel with a sulphur content of 10 mg/kg or less has been used in the analysis as most diesel used in Germany is of this type. **b** The LPG price is a simple average of weekly price data from the European Commission (2011a).

Sources: EC (2011a); Energy Balances Working Group (2011); Federal Ministry of Economics and Technology (Germany) (2010); Productivity Commission estimates.

Results

Estimated consumption costs and abatement for fuel taxes in Germany are presented in table O.12. Average consumption costs (per tonne of abatement) are presented in table O.13.

Table O.12 **Consumption costs and abatement**
Germany, 2009

Elasticity	*Reduction in fuel consumption*		*Consumption cost*		*Abatement*
	ML	ML petrol equivalent	€m (2009)	A$m (2010)	Mt CO_2-e
Petrol					
Low	5 011	5 011	1 397	2 017	14
High	18 174	18 174	4 722	6 813	50
Diesel					
Low	4 728	5 272	982	1 417	15
High	16 445	18 335	3 236	4 669	52
LPG					
Low	45	35	2	3	0.1
High	141	111	7	10	0.3

Source: Productivity Commission estimates.

Table O.13 **Average consumption costs**
Germany, 2009

Elasticity	*Reduction in fuel consumption*	*Consumption cost*		*Abatement*	*Average consumption cost*
	ML petrol equivalent	€m (2009)	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Low	10 318	2 382	3 437	29	119
High	36 619	7 964	11 492	102	113

Source: Productivity Commission estimates.

O.5 Japan

Japan levies excise on road transport fuels at the national level. The tax on petrol consists of two components (the Gasoline Tax and the Local Gasoline Tax) (table O.14). The tax on diesel is collected at the prefectural level.

In addition, the Petroleum and Coal Tax has been identified as an emissions-reduction measure in Japan (chapter 2). This tax is levied on the petroleum (crude oil) used as an input by refineries, as well as on imports of refined products (such as petrol and diesel) (box O.4). As most transport fuels in Japan are either directly imported or produced from imported petroleum, this tax is likely to impact most fuel sold. That said, it has not been included in the analysis below, as Japan imports substantially more petroleum (for domestic refining) than it does refined products (IEA 2010e). This suggests that the Petroleum and Coal Tax is mostly an input tax that is not directly levied on retail sales of road transport fuels.

Moreover, the effect on retail prices is uncertain and could depend on refining processes and the ability of refiners and importers to pass the costs through to consumers.

Table O.14 **Fuel excise rates**
Japan, 2011

Tax	*Excise rate*
	¥/L
Gasoline Tax	48.6
Local Gasoline Tax	5.2
Diesel Handling Tax	32.1
Liquefied Petroleum Gas Tax	17.5[a]

a Rate is per kilogram.

Sources: JAMA (2010); Ministry of Finance (Japan) (2010a).

Estimating consumption costs and abatement

Consumption costs and abatement for fuel taxes in Japan were estimated for fiscal year 2009 (April 2009 to March 2010). Some tax, revenue and price data were provided to the Commission by the Institute of Energy Economics, Japan (IEEJ).

Average retail prices, excise rates and excise revenues for Japan are provided in table O.15, along with the implied level of taxed consumption for each fuel (calculated by dividing the revenue values by the excise rates).

Box O.4 **Petroleum and Coal Tax**

The Petroleum and Coal Tax in Japan taxes imports of petroleum (crude oil) at ¥2.04/L (A$0.02/L) and imports of petroleum gas at ¥1.08/kg (A$0.01/kg) (Ministry of Finance (Japan) 2010a). This tax is levied on imports of both petroleum and refined fuels (such as petrol or diesel). Since Japan produces only a small amount of oil domestically (IEA 2010e), most transport fuel would be affected.

Under a current legislative proposal — the 'Special Provision on Taxation for Global Warming Countermeasure' — the rate of tax will be increased based on the emissions content of fuels (that is, the volume of carbon dioxide that would be generated when combusting each type of fuel). The amount of the increase will gradually increase between April 2013 and April 2015, to a rate of ¥289/t CO_2 (A$3.53). This will translate to a tax of ¥0.76/L (A$0.01/L) of refined petrol or diesel imports, and ¥0.78/kg (A$0.01/kg) of imported LPG.

Sources: Ministry of Finance (Japan) (2010a); Ministry of Environment (Japan) (pers. comm., 25 April, 2 May and 19 May 2011); IEEJ (pers. comm., 14 April 2011); IEA (2010e).

Table O.15 **Fuel taxes**

Japan, April 2009 – March 2010

Fuel type	*Average retail price*	*Excise rate*	*Excise revenue*[a]	*Implied level of taxed consumption*
	¥/L	¥/L	¥b (2009)	ML
Petrol	134.8	53.80	2 948	54 796
Diesel	112.7	32.10	908	2 830
LPG	79.3[b]	9.63	26	2 701

[a] Excise revenue data for petrol and LPG are from Ministry of Finance (Japan) (2010a). The figure for diesel was provided by the IEEJ (pers. comm., 14 April 2011). [b] Average of prices, for every second month, from April 2009 to March 2010 provided by the IEEJ (pers. comm., 14 April 2011).

Sources: IEEJ (pers. comm., 14 April 2011); Ministry of Finance (Japan) (2010a; 2010b); Oil Information Center (2011); Productivity Commission estimates.

Results

Estimated consumption costs and abatement for fuel taxes in Japan are presented in table O.16. Average consumption costs (per tonne of abatement) are presented in table O.17.

Table O.16 **Consumption costs and abatement**

Japan, April 2009 – March 2010

Elasticity	*Reduction in fuel consumption*		*Consumption cost*		*Abatement*
	ML	ML petrol equivalent	¥b (2009)	A$m (2010)	Mt CO_2-e
Petrol					
Low	7 441	7 441	179	2 188	20
High	25 492	25 492	585	7 143	70
Diesel					
Low	247	273	4	45	0.7
High	809	892	12	143	2.3
LPG					
Low	89	70	0.4	5	0.2
High	275	217	1.3	16	0.5

Source: Productivity Commission estimates.

Table O.17 **Average consumption costs**

Japan, April 2009 – March 2010

Elasticity	*Reduction in fuel consumption*	*Consumption cost*		*Abatement*	*Average consumption cost*
	ML petrol equivalent	¥b (2009)	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Low	7 784	183	2 238	21	105
High	26 601	596	7 301	73	100

Source: Productivity Commission estimates.

O.6 New Zealand

New Zealand levies several taxes on transport fuels, including excise and levies, as well as the New Zealand ETS.

Excises on petrol consist of the Excise Duty on Motor Spirits, the Accident Compensation Corporation Levy, the Petroleum or Engine Fuels Monitoring Levy and the Local Authority Petroleum Tax (table O.18). Since 1991, the excise on diesel has been considerably lower than that on petrol. This is due to changes to taxation arrangements so that diesel vehicles are now primarily taxed through the Road User Charges system (where permits must be purchased for each 1000 kilometres travelled, with the charge depending on the type and weight of the vehicle).

Table O.18 **Excise on road transport fuels**

New Zealand, 2011

Fuel type	*Excise Duty on Motor Spirits*	*Accident Compensation Corporation Levy*	*Petroleum or Engine Fuels Monitoring Levy*	*Local Authority Petroleum Tax*	*Total excise*
	NZ$/L	NZ$/L	NZ$/L	NZ$/L	NZ$/L
Petrol	0.48524	0.099	0.00045	0.0066	0.59129
Diesel	–	–	0.00045	0.0033	0.00375
LPG	0.104	–	–	–	0.104
CNG	0.105	–	–	–	0.105
Methanol	0.302	–	–	0.0066	0.3068

– Nil or rounded to zero.

Source: MED (NZ) (2011c).

The New Zealand ETS covers liquid fossil fuels, which includes most road transport fuels. Fuel suppliers (which purchase fuels from refineries or import fuels) are

required to surrender permits to cover the 'downstream' emissions of fuels when they are combusted by purchasers of fuel, such as businesses or consumers.

Estimating consumption costs and abatement

Consumption costs and abatement for fuel taxes in New Zealand were estimated jointly for both fuel excise and the New Zealand ETS for the 2010 calendar year.

Fuel prices and tax rates

Excise rates and New Zealand ETS obligations have varied over 2010. As a result, the reduction in fuel consumption and consumption costs were estimated on a 'quarterly' basis (for four three-month periods in 2010). These estimates were then summed to provide annual figures (table O.19).

Key changes throughout 2010 were:

- The Excise Duty on Motor Spirits was increased by three cents per litre on 1 October 2010 (from NZ$0.45524/L to NZ$0.48524/L) (MED (NZ) 2011c). This means that the rate was higher in the fourth quarter (October to December) than in the first three quarters (January to September).
- Transport fuel suppliers have been liable to surrender ETS permits since 1 July 2010. This means that, in 2010, the ETS effectively taxed transport fuels only between July and December (third and fourth quarters). This is reported by MED (NZ) (2011e) for petrol and diesel on a weekly basis as an 'ETS charge' — the average amount that is passed on to the retail prices of petrol and diesel.

Quantity of taxed fuels used in road transport

In order to estimate the quantity of taxed road transport fuels consumed, several assumptions were required. Total fuel consumption data (MED (NZ) 2011d) were not used as these include the use of fuels outside of road transport.

Instead, excise revenue data were used to estimate the volume of taxed fuel in each quarter. Revenue data for domestically refined fuels are published by month for 2010 but not by fuel type (New Zealand Treasury 2010b). Revenue data for the customs duty on imported fuels (the duty is at the same rate as the excise) is only available as an annual figure, for financial year 2009-10 (July 2009 to June 2010) (New Zealand Treasury 2010a).

Table O.19 **Fuel excise, 'ETS charges' and average fuel prices[a]**
New Zealand, 2010

	Excise	*Average 'ETS charge'[b]*	*Total*	*Average fuel price[c]*
	NZ$/L	NZ$/L	NZ$/L	NZ$/L
First quarter (January – March)				
Petrol	0.56129	..	0.56129	1.77
Diesel	0.00375	..	0.00375	1.12
LPG	0.104	..	0.104	1.21
Second quarter (April – June)				
Petrol	0.56129	..	0.56129	1.78
Diesel	0.00375	..	0.00375	1.18
LPG	0.104	..	0.104	1.21
Third quarter (July – September)				
Petrol	0.56129	0.0207	0.58199	1.76
Diesel	0.00375	0.0239	0.02765	1.19
LPG	0.104	0.0147	0.1187	1.23
Fourth quarter (October – December)				
Petrol	0.59129	0.0235	0.61479	1.89
Diesel	0.00375	0.0272	0.03095	1.27
LPG	0.104	0.0160	0.1200	1.26

a Fuel prices and average 'ETS charges' for petrol and diesel are simple averages based on weekly data for each quarter from MED (NZ) (2011e). **b** An 'ETS charge' has not been reported for LPG, hence the value has been estimated by multiplying an estimate of the direct emissions from LPG (1793 g CO_2-e/L; appendix M) by half the average quarterly permit price in each quarter (AEA Technology pers. comm., 24 March 2011) (as one permit could be surrendered to cover two tonnes of transport fuel emissions in 2010). **c** Petrol prices are for 'regular petrol'. The LPG price is a simple average of monthly data for Wellington, provided by the New Zealand Automobile Association (Ministry for the Environment (New Zealand) pers. comm., 27 April 2011). **..** Not applicable.

Sources: MED (NZ) (2011c; 2011e); AEA Technology (pers. comm., 24 March 2011); Ministry for the Environment (New Zealand) (pers. comm., 27 April 2011); Appendix M; Productivity Commission estimates.

Estimates of revenues for each fuel type were calculated by first estimating total revenues in each quarter. This was done by summing excise revenues from domestically-refined fuels for the three months in each quarter, then adding an amount for the excise from imported fuels (calculated by dividing the customs duty revenue figure for 2009-10 by four, and assuming that revenues would be the same over calendar year 2010).

These quarterly estimates were then apportioned across fuel types by assuming that the proportion of total fuel use that was taxed and used for road transport was the same for each fuel type. (That said, a greater proportion of diesel fuel may be used

outside of road transport than other fuel types, and thus the revenue from diesel may be overestimated.) The estimates of revenue by fuel type were then divided by the excise rate to impute the quantity of taxed fuel used for road transport (table O.20).

Table O.20 **Estimated quantities of taxed road transport fuels**
New Zealand, 2010

	Total excise	*Supply from wholesalers*[a]	*Imputed weight (share of revenue)*[b]	*Estimated excise revenue*[c]	*Estimated quantity of taxed road transport fuel*
	NZ$/L	ML	%	NZ$m (2010)	ML
First quarter (January – March)					
Total	..	..	..	353	..
Petrol	0.56129	802.7	0.98	347	6 186
Diesel	0.00375	659.2	0.01	2	507
LPG	0.104	49.0	0.01	4	38
Second quarter (April – June)					
Total	..	..	..	358	..
Petrol	0.56129	766.3	0.98	351	625
Diesel	0.00375	642.2	0.01	2	523
LPG	0.104	58.8	0.01	5	48
Third quarter (July – September)					
Total	..	..	..	396	..
Petrol	0.56129	766.0	0.97	385	685
Diesel	0.00375	669.5	0.01	2	599
LPG	0.104	93.7	0.02	9	84
Fourth quarter (October – December)					
Total	..	..	..	348	..
Petrol	0.59129	812.6	0.98	342	578
Diesel	0.00375	747.4	0.01	2	531
LPG	0.104	53.8	0.01	4	38

a 'Total domestic consumption' data from MED (NZ) (2011d), derived from a survey of the five fuel wholesalers in New Zealand. **b** The weights used to apportion quarterly revenue between fuel types were constructed by calculating what the revenue share of each would have been if all fuel supplied by wholesalers was subject to excise. For each quarter, this was done by multiplying the excise rate of each fuel type by the wholesale supply of that fuel (this gives the numerators for the weights; the sum of these values over all fuels gives the denominator). **c** Quarterly total excise revenues are based on monthly data from the New Zealand Treasury (2010a) for excise on domestically refined fuels, and an estimate based on an annual figure for 2009-10 for duty on imported fuels, also reported by the New Zealand Treasury (2010a). Consumption data for CNG and methanol used for road transport were not available. It was assumed that revenue from tax on these fuels was negligible. **..** Not applicable.

Sources: MED (NZ) (2011c; 2011d); New Zealand Treasury (2010a; 2010b); Productivity Commission estimates.

Results

Estimated consumption costs and abatement for fuel taxes in New Zealand are presented in table O.21. Average consumption costs (per tonne of abatement) are presented in table O.22.

Table O.21 **Consumption costs and abatement**
New Zealand, 2010

Elasticity	*Reduction in fuel consumption*		*Consumption cost*		*Abatement*
	ML	ML petrol equivalent	NZ$m (2010)	A$m (2010)	Mt CO_2-e
Petrol					
Low	259	259	69	54	0.7
High	859	859	221	173	2.3
Diesel					
Low	8	8	0.1	0.1	0.02
High	23	25	0.3	0.2	0.07
LPG					
Low	5	4	0.3	0.2	0.01
High	16	12	0.9	0.7	0.03

Source: Productivity Commission estimates.

Table O.22 **Average consumption costs**
New Zealand, 2010

Elasticity	*Reduction in fuel consumption*	*Consumption cost*		*Abatement*	*Average consumption cost*
	ML petrol equivalent	NZ$m (2010)	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Low	271	69	54	0.7	73
High	896	222	174	2.4	71

Source: Productivity Commission estimates.

O.7 South Korea

South Korea levies several taxes on petrol and diesel: the Transportation, Energy, Environment Tax; the Education Tax; and the Motor Fuel Tax (table O.23).

Estimating consumption costs and abatement

Consumption costs and abatement for fuel taxes in South Korea were estimated for the 2009 calendar year. Data on fuel taxes, average retail prices and the volume of

taxed fuel used for road transport were provided to the Commission by the Korean Energy Economics Institute (KEEI).

Table O.23 **Fuel tax rates[a]**
South Korea, 2011

Fuel type	*Transportation, Energy, Environment Tax*	*Education Tax*	*Motor Fuel Tax*	*Other volumetric taxes*	*Total*
	KRW/L	KRW/L	KRW/L	KRW/L	KRW/L
Petrol	529.00	79.35	137.54	..	745.89
Diesel	367.50	55.13	95.55	..	518.18
LPG	..	24.09	..	196.97	221.06

a These tax rates have applied since 21 May 2009. **..** Not applicable.

Source: KEEI (pers. comm., 26 April and 27 April 2011).

Fuel prices, taxes and the level of taxed consumption are provided in table O.24. The fuel tax rates on petrol and diesel increased on 21 May 2009 to the levels shown in the table. However, data were not available on average prices and taxed consumption for the separate periods either side of this tax change (1 January to 20 May, and 21 May to 31 December). The higher (more recent) rates have been used in the analysis since they applied for a longer period of time, although in consequence, the results reported below may be overestimates.

Table O.24 **Fuel taxes**
South Korea, 2009

Fuel type	*Average retail price*	*Tax rate*	*Level of taxed consumption*
	KRW/L	KRW/L	ML
Petrol	1 601	745.89	10 132
Diesel	1 398	518.18	15 855
LPG	829	221.06	7 782

Sources: KEEI (2010b; pers. comm., 26 April and 27 April 2011).

Results

Estimated consumption costs and abatement for fuel taxes in South Korea are presented in table O.25. Average consumption costs (per tonne of abatement) are presented in table O.26.

Table O.25 **Consumption costs and abatement**
South Korea, 2009

Elasticity	*Reduction in fuel consumption*		*Consumption cost*		*Abatement*
	ML	ML petrol equivalent	KRW b (2009)	A$m (2010)	Mt CO_2-e
Petrol					
Low	1 720	1 720	558	541	5
High	6 087	6 087	1 859	1 801	17
Diesel					
Low	1 947	2 203	456	442	6
High	6 588	7 453	1 477	1 432	20
LPG					
Low	628	515	65	63	1
High	2 039	1 674	205	199	4

Source: Productivity Commission estimates.

Table O.26 **Average consumption costs**
South Korea, 2009

Elasticity	*Reduction in fuel consumption*	*Consumption cost*		*Abatement*	*Average consumption cost*
	ML petrol equivalent	KRW b (2009)	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Low	4 438	1 079	1 046	12	87
High	15 214	3 541	3 432	41	83

Source: Productivity Commission estimates.

O.8 United Kingdom

The United Kingdom levies excise on fuels for road transport at the rates set out in table O.27.

Estimating consumption costs and abatement

Consumption costs and abatement for fuel taxes in the United Kingdom were estimated for the 2010 calendar year. As rates of fuel duty changed twice during this year, in April and October (table O.28), the reduction in fuel consumption and consumption costs were estimated on a monthly basis for the United Kingdom. Estimates were then summed to provide annual figures.

Table O.27 **Fuel duty rates**
United Kingdom, 2011[a]

Fuel type	*Duty rate*
	£/L
Unleaded petrol	0.5795
Leaded petrol	0.6767
Diesel	0.5795
Bioethanol	0.5795
Biodiesel / blended	0.5795
Natural gas	0.2470[b]
All other gases	0.3161[b]

[a] Rates were effective from 23 March 2011. [b] Rates are per kilogram.

Source: HM Revenue and Customs (UK) (2011).

The quantity of each fuel consumed was imputed using monthly revenue data (HM Revenue and Customs (UK) 2011). Detailed revenue data were not available for LPG, although revenue data are published for 'road fuel gases', which consists mostly of LPG but also includes natural gas used by road transport. Therefore, some results for LPG in the analysis may be overstated.

Table O.28 **Dates of fuel duty rate changes**
United Kingdom, 2009–2011

Fuel type	*1 September 2009*	*1 April 2010*	*1 October 2010*	*1 January 2011*
	£/L	£/L	£/L	£/L
Petrol	0.5619	0.5719	0.5819	0.5895
Diesel	0.5619	0.5719	0.5819	0.5895
LPG[a]	0.1496	0.1651	0.1728	0.1787

[a] Rates are for 'all other gases' under the road fuel gases category.

Source: HM Revenue and Customs (UK) (2011).

Average fuel prices, excise rates and fuel duty revenues are shown in table O.29. Average prices for petrol were available only for two separate grades (super unleaded and premium unleaded), and for each month an average price was used, weighted using quarterly consumption data of each fuel type (DECC (UK) 2011a).

Table O.29 **Fuel taxes**[a]

United Kingdom, 2010

Fuel type	*Average retail price*	*Excise rate*	*Excise revenue*
	£/L	£/L	£m (2010)
Petrol	1.17[b]	0.5721	11 430
Diesel	1.19	0.5722	14 119
LPG	0.64	0.1635	32

a Prices and excise rates are averages based on monthly data, weighted using the implied level of taxed consumption in each month. **b** Average of super unleaded and premium unleaded prices, weighted using quarterly data on consumption of each fuel type (DECC (UK) 2011a).

Sources: HM Revenue and Customs (UK) (2011); DECC (UK) (2011a; 2011b); Automobile Association (2011); Productivity Commission estimates.

Results

Estimated consumption costs and abatement for fuel taxes in the United Kingdom are presented in table O.30. Average consumption costs (per tonne of abatement) are presented in table O.31.

Table O.30 **Consumption costs and abatement**

United Kingdom, 2010

Elasticity	*Reduction in fuel consumption*		*Consumption cost*		*Abatement*
	ML	ML petrol equivalent	£m (2010)	A$m (2010)	Mt CO_2-e
Petrol					
Low	3 641	3 641	897	1 504	10
High	13 037	13 037	3 008	5 044	36
Diesel					
Low	4 379	4 793	1 083	1 816	14
High	15 610	17 085	3 622	6 074	50
LPG					
Low	15	12	1.1	1.9	0.02
High	48	37	3.6	6.0	0.08

Source: Productivity Commission estimates.

Table O.31 **Average consumption costs**
United Kingdom, 2010

Elasticity	*Reduction in fuel consumption*	*Consumption cost*		*Abatement*	*Average abatement cost*
	ML petrol equivalent	£m (2010)	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Low	8 446	1 981	3 323	24	139
High	30 159	6 634	11 125	85	130

Source: Productivity Commission estimates.

O.9 United States

Fuel taxes in the United States are levied at the federal, state and local levels. Federal excise taxes are listed in table O.32. State tax rates are listed in table O.38 in the annex, although fuel tax systems differ between states (box O.5). In addition, there are also consumption taxes (at state and local levels), and local-level excise taxes.

At the federal level and in most states, petrol blended with ethanol — termed 'gasohol' in the United States, and usually containing 10 per cent ethanol (E10) — is taxed at the same rate per litre as petrol. However, the tax is lower in some states, which effectively subsidises the consumption of ethanol (appendix N).

Table O.32 **Federal fuel excise**
United States, December 2010

Fuel type	*Excise rate*
	US$/gallon
Gasoline[a]	0.184
Diesel	0.244
LPG	0.183
'P series' fuel	0.184
Compressed natural gas	0.183
Liquefied hydrogen	0.184
Liquid fuel derived from coal (including peat) through the Fischer-Tropsch process	0.244
Liquid fuel derived from biomass	0.244
Liquefied natural gas	0.243

a Includes blends of petrol with alcohol (such as ethanol).

Source: IRS (US) (2011).

Box O.5 **State fuel tax systems in the United States**

Fuel tax systems differ in design between states. On average, volumetric taxes are approximately US$0.21/gallon (A$0.06/L) of petrol and diesel, and US$0.10/gallon (A$0.03/L) of LPG. Some states also impose consumption taxes ('sales taxes') or Local Option Taxes on fuel (the latter are levied at the county or city level).

In addition, many states provide exemptions to state-level volumetric taxes.

- Ten states do not impose volumetric taxes on LPG, and nine states (plus the District of Columbia) have a lower tax rate on E10 'gasohol' than on petrol (as of December 2010).
- LPG vehicles that are registered in some states pay an annual fee instead of the volumetric fuel tax (and thus not all LPG fuel sold for use in road transport is subject to state-level fuel taxes).
- Several states impose additional volumetric taxes for 'motor carriers' (such as freight companies), or vehicles above a certain weight or number of axles.
- Some states adjust fuel tax rates on a periodic basis, whereas others states have not changed rates for several years or even decades.
- Some states exempt fuels from state-wide consumption taxes if the fuel is subject to the volumetric fuel tax.

As consistent data were not available on the full extent of such exemptions across states, the Commission has used the full excise rate in its analysis.

Source: FHWA (US) (2011b).

Transport fuels may also be subject to emissions trading schemes in the future. For example, the Californian ETS is scheduled for implementation in 2012 and will cover transport fuels from 2015. Obligations for fuel suppliers to surrender permits are likely to lead to higher prices for petrol, diesel and LPG in California.

Estimating consumption costs and abatement

Consumption costs and abatement for fuel taxes in the United States were estimated for the 2009 calendar year using a separate analysis for each state (plus the District of Columbia), by fuel type. These results were then summed to provide national-level estimates.

The following data were used for each state, by fuel type.

- The total (federal plus state) volumetric tax rate per litre (FHWA (US) 2011a).
- The average retail fuel price (EIA (US) 2011n).

  - These estimates are based on average pre-tax prices calculated by the Energy Information Administration, and include federal and state volumetric taxes but not sales taxes (EIA (US) 2010e). As a result, the price estimates are likely to be lower than observed retail prices, although this is not expected to significantly affect the results of the analysis as the excluded taxes are similarly excluded from the tax rate data used.[2]

- The taxed volume of each fuel (that is consumed for road transport).
  - Values for petrol are taxed volumes of gasoline used as a motor fuel in each state (FHWA (US) 2011a). (These volumes include the consumption of 'gasohol', and thus are likely to overstate the actual amount of taxed petrol consumption.)
  - Values for diesel and LPG in each state were estimated as taxed volumes of other fuels are reported by the Federal Highway Administration only as a combined (aggregated) value for each state ('special fuels'). The taxed volume of special fuels in each state was divided by the sum of diesel and LPG used in all forms of transport in that state (EIA (US) 2011n) to estimate the proportion of these fuels that were taxed. These values were then multiplied by the volumes of diesel and LPG (respectively) that were consumed in all transport to estimate the taxed volumes that were consumed in road transport.

The Commission has not included the impact of the California ETS in its estimates as detailed information on the estimated impact of this scheme on the price of each fuel type (in the initial year of 2015) were not available. However, it is likely that this ETS will raise fuel prices in California, and thus reduce fuel consumption and emissions (box O.6).

2 In other words, the two effects 'cancel out' mathematically. In the formulae for the change in quantity and consumption costs (as set out in box O.1), scaling both the counterfactual price p and tax rate t by a common factor does not change the result for the change in quantity or change in consumer surplus.

Box O.6 **California Cap-and-Trade Scheme**

The California Cap-and-Trade ETS (part of the Western Climate Initiative) is expected to commence in California in 2012. Transport fuels will be included in the scheme from 2015.

The California Air Resources Board (CARB) has conducted economic modelling of the scheme to estimate the impact on covered sectors over the period 2012–2020. This analysis includes transport fuels (petrol and diesel) over the period 2015–2020.

The ETS was compared to a 'reference' case or counterfactual where it is not implemented. This reference case includes two other transport-sector policies: the Federal Renewable Fuel Standard and the Pavley I Vehicle Standards (fuel efficiency standards for new cars and light trucks).

The central projection is the CARB's estimate of the most likely outcome over the period 2012–2020. This used an ETS 'allowance' (permit) price of US$25/t CO_2-e in 2020 — where emissions in all covered sectors are capped at 1990 levels — and assumed that allowances can be banked and offsets can be used for compliance.

This projection also included several 'complementary' policies in addition to the ETS — Pavley II Vehicle Standards, the Low Carbon Fuel Standard and the Vehicle Miles Travelled Reduction Measure (which consists of urban planning policies) (CARB (US) 2010). Overall, it was estimated that complementary policies would account for around two-thirds of abatement over the 2012–2020 period, with the remainder due to the ETS (CARB (US) 2010).

Some modelling results for 2020 under the central projection are presented in the table (these results include the complementary policies in addition to the ETS on transport fuels from 2015). Overall, passenger-miles travelled in 2020 are expected to be 4 per cent lower than the reference case, and freight tonne-miles 2 per cent higher.

In addition, the modelling results also suggest that the allowance price will be around US$18/t CO_2-e (in 2007 dollars) in 2015 (equivalent to A$20 in 2010 dollars), the first year in which transport fuels will be covered by the scheme (calculated using a formula published by CARB (US) (2010).

Fuel type	*2020 reference price*	*2020 fuel price increase from reference*	*2010 fuel demand decrease from reference*
	2007 US$/gallon	%	%
Petrol	3.20	5.4	18
Diesel	6.02	3.0	17

Source: CARB (US) (2010).

Results

Estimated consumption costs and abatement for fuel taxes in the United States are presented in table O.33. Average consumption costs (per tonne of abatement) are presented in table O.34.

Table O.33 **Consumption costs and abatement**
United States, 2009

Elasticity	*Reduction in fuel consumption*		*Consumption cost*		*Abatement*
	ML	ML petrol equivalent	US$m (2009)	A$m (2010)	Mt CO_2-e
Petrol					
Low	24 183	24 183	1 226	1 346	70
High	76 159	76 159	3 801	4 171	221
Diesel					
Low	6 586	7 406	365	401	20
High	20 780	23 366	1 133	1 243	70
LPG					
Low	45	31	2	2	0.1
High	140	98	6	7	0.3

Source: Productivity Commission estimates.

Table O.34 **Average consumption costs**
United States, 2009

Elasticity	*Reduction in fuel consumption*	*Consumption cost*		*Abatement*	*Average consumption cost*
	ML petrol equivalent	US$m (2009)	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Low	31 621	1 594	1 749	92	19
High	99 623	4 940	5 421	291	19

Source: Productivity Commission estimates.

O.10 Demand-side abatement from biofuel policies

This section provides illustrative estimates of demand-side abatement, the reduction in fuel consumption, and consumption costs for the biofuel policies that are analysed in appendix N (for the supply side). Key data 'inputs' are presented in table O.35, including any calculations that were required (such as the estimated price uplift).

Table O.35 **Estimated price impact, biofuel policies**

Germany (2009), United Kingdom (April 2009 – March 2010), United States (2009)

Country	*Subsidy equivalent*	*Quantity of biofuel*	*Estimated price uplift*[a]	*Quantity of blended fuel*[b]	*Life-cycle emissions intensity*[c]
	A$m (2010)	ML petrol equivalent	A$/L	ML	g CO_2-e/L
Germany					
Ethanol	533	754	0.02	26 506	2 722
United Kingdom					
Ethanol	209	296	0.01	21 516	2 709
Biodiesel	465	1 123	0.02	27 576	2 844
United States					
Ethanol	7 321	28 016	0.01	513 004	2 859
Biodiesel	472	1 256	0.002	150 889	2 642

[a] Estimated increase in the price of biofuel-blended petrol (in the case of ethanol) or diesel (in the case of biodiesel) due to fuel content mandates. [b] The quantity of blended fuel in Germany and the United Kingdom was calculated as the sum of biofuel consumption and conventional fuel consumption (for example, ethanol plus petrol consumption), and expressed in either litres of petrol (for ethanol) or litres of diesel (biodiesel), after adjustment for the energy content of biofuels. For the United States, reported volumes of petrol sold include ethanol (blended with petrol). It was assumed that reported volumes of diesel similarly include biodiesel. [c] Average of the emissions intensity values for biofuels used for each country in the supply-side analysis (appendix N), weighted by the energy-adjusted volume of each fuel type consumed.

Source: Productivity Commission estimates.

Results

The results are set out in table O.36. In general, the estimates are low (relative to those for fuel taxes) because the total subsidy equivalent for biofuel mandates in each country is being divided by a large volume of total fuel consumption (this is reflected by the small increase in fuel prices).

Table O.36 **Average consumption costs, biofuel policies**

Germany (2009), United Kingdom (April 2009 – March 2010), United States (2009)

Elasticity	*Reduction in fuel consumption*	*Consumption cost*	*Abatement*	*Average consumption cost*
	ML petrol equivalent	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Germany				
Ethanol				
Low	105	2	0.3	5
High	317	5	0.9	5
United Kingdom				
Ethanol				
Low	53	0.4	0.1	3
High	159	1	0.4	3
Biodiesel				
Low	95	1	0.3	5
High	285	4	0.8	5
United States				
Ethanol				
Low	988	8	3	3
High	2 473	19	7	3
Biodiesel				
Low	47	0.1	0.1	0.46
High	118	0.2	0.4	0.46

Source: Productivity Commission estimates.

O.11 Review of the literature on fuel demand elasticities

There is an extensive literature that has estimated the own-price elasticity of demand for transport fuels. The results of different studies vary significantly, depending on the country or countries analysed, the data set used, the period of analysis and the methodology.

This section provides an overview of the literature, including estimates from selected studies. Given the volume of literature and the wide range of estimates, the estimates that are cited below are provided as illustrative of that literature. While they are intended to reflect general findings, these values do not necessarily reflect all available estimates for a given country or time period.

Meta-analyses and cross-country studies

Several studies have examined the findings of a range of literature and drawn comparisons between results. A summary of results from meta-analyses — which

collate the findings of other studies and undertake statistical analysis — is presented in table O.37.

Table O.37 **Elasticities of fuel demand**
Estimates published in selected meta-analyses

Source	*Short term*	*Long term*
Brons et al. (2008)	-0.34	-0.84
Dahl (2011)	-0.11 to -0.33	..
Espey (1998)	-0.26	-0.58
Goodwin, Dargay and Hanly (2004)	-0.25 to -0.43	-0.64
Graham and Glaister (2002)	-0.2 to -0.3	-0.6 to -0.8
Graham and Glaister (2004)	-0.25	-0.7

.. Not applicable.

The meta-analysis by Goodwin, Dargay and Hanly (2004) reviewed 69 empirical studies of transport elasticities. While there was a large range of results across studies, the overall assessment of the authors was that a 10 per cent rise in fuel prices leads to a reduction in fuel consumption of 2.5 per cent within a year, and a reduction of at least 6 per cent in the longer term. Graham and Glaister (2002) used a similar approach to conclude that the elasticity of fuel demand is less elastic in the short term (-0.2 to -0.3) than in the long term (-0.6 to -0.8). However, they also note that the results of different studies are not strictly comparable due to differences in the methodologies used.

A different approach was used by Brons et al. (2008) to analyse the literature by examining three factors that influence the demand for fuel: the fuel-efficiency of vehicles, the distance travelled by each vehicle (mileage), and the rate of vehicle ownership. Overall, they found that the average elasticity of fuel is around -0.34 in the short term and -0.84 in the long term. In the short term, they found that fuel efficiency and mileage can explain most of the responsiveness of fuel demand to changes in price, whereas in the longer term changes in vehicle ownership have a relatively greater effect on fuel demand.

However, the elasticity values reported by these meta-analyses are averages across a number of other studies. The range of estimates is thus considerably larger across individual studies than across meta-analyses.

Country-specific studies

Elasticity values that were estimated in various studies tend to differ depending on the country being analysed. For example, Hensher and Li (2010) found that petrol demand is more responsive to price changes in Europe than in Australia and the

United States, which they suggest is due to higher fuel prices (due to fuel taxes) and a greater prevalence of public transport in Europe. Other studies have found that fuel demand is relatively less inelastic in Germany compared to other countries, and within the range -0.45 to -0.67 (Frondel, Peters and Vance 2008; Frondel and Vance 2010).

Estimates for the United States suggest the demand for fuel is relatively inelastic, over both the short and long term. For example, Hughes, Knittel and Sperling (2008) estimated elasticity values of -0.03 to -0.08 over the period 2001–2006. Over the longer term, Small and van Dender (2007) estimated an elasticity of -0.36 (covering the period 1966–2004). That said, Hughes, Knittel and Sperling (2008) also provide some evidence that fuel demand has become less elastic over time in the United States, due to increased dependence on vehicles, changes in settlement patterns and increases in the fuel efficiency of vehicles.

Studies have also found that fuel demand is relatively inelastic in Australia and New Zealand. For example, the Bureau of Infrastructure, Transport and Regional Economics (BITRE 2009) estimated a short-term elasticity of -0.16 and a longer-term elasticity of -0.45 for Australia. Similarly, Breunig and Murphy (2009) estimated that short-term elasticities range from -0.13 to -0.14 for Australia, while long-term elasticities range from -0.2 to -0.3. Similar figures have been found for New Zealand, with Kennedy and Wallis (2007) reporting estimates of -0.15 in the short term and -0.2 over longer time periods.

There is less evidence available for China, Japan and South Korea, and estimates vary across these countries. For example, Cheung and Thomson (2004) examined petrol demand in China over the period 1980–1999, estimating the short-term elasticity of demand at -0.19 and the long-term elasticity at -0.56. This short-term estimate is comparable to those reported by Dahl (2011) for China (-0.26) and Japan (-0.15), and by Clerides and Zachariadis (2008) for Japan (-0.17). The long-term estimate for China is similar to long-term estimates for South Korea reported by Kim, Han and Moon (2011) (-0.44 to -0.88).

Fuel types

Few studies report estimates of the elasticity of fuel demand for separate fuel types (such as petrol, diesel or LPG). The majority of studies provide estimates only for all transport fuels combined (for example, Frondel and Vance 2010; Goodwin, Dargay and Hanly 2004). However, figures cited by Dahl (2011) suggest that the demand for diesel is relatively more elastic than that for petrol in Australia, Germany, Japan, New Zealand and the United Kingdom, but relatively less elastic in China, South Korea and the United States.

Annex

Table O.38 **State volumetric fuel taxes[a]**

United States, December 2010

State	*Petrol*	*Gasohol (E10)[b]*	*Diesel*	*LPG*
	US$/gallon	US$/gallon	US$/gallon	US$/gallon
Alabama	0.1800	0.1800	0.1900	–
Alaska	0.0800	0.0800	0.0800	–
Arizona	0.1800	0.1800	0.2600	–
Arkansas	0.2150	0.2150	0.2250	0.1650
California	0.1800	0.3530	0.1800	0.0600
Colorado	0.2200	0.2200	0.2050	0.2050
Connecticut	0.2500	0.2500	0.3960	–
Delaware	0.2300	0.2300	0.2200	0.2200
District of Columbia	0.2350	0.2000	0.2000	0.2000
Florida	0.1600	0.1600	0.1600	0.1450
Georgia	0.0750	0.0750	0.0750	0.0750
Hawaii	0.1700	0.1600	0.1700	0.0520
Idaho	0.2500	0.2500	0.2500	0.1810
Illinois	0.1900	0.1900	0.2150	0.1900
Indiana	0.1800	0.1800	0.1600	–
Iowa	0.2100	0.1900	0.2250	0.2000
Kansas	0.2400	0.2400	0.2600	0.2300
Kentucky	0.2560	0.2560	0.2260	0.2420
Louisiana	0.2000	0.2000	0.2000	0.1600
Maine	0.2950	0.2300	0.3070	–
Maryland	0.2350	–	0.2425	–
Massachusetts	0.2100	0.2100	0.2100	0.2500
Michigan	0.1900	–	0.1500	0.1500
Minnesota	0.2750	0.2750	0.2750	0.2063
Mississippi	0.1840	0.1840	0.1840	0.1700
Missouri	0.1700	0.1700	0.1700	0.1700
Montana	0.2775	0.2375	0.2850	–
Nebraska	0.2710	0.2710	0.2710	0.2710
Nevada	0.2400	0.2400	0.2700	0.2200
New Hampshire	0.1800	0.1963	0.1800	–
New Jersey	0.1050	0.1050	0.1350	0.0525
New Mexico	0.1888	0.1888	0.2288	0.1200
New York	0.2435	–	0.2255	0.0805
North Carolina	0.3215	0.3215	0.3215	0.2710
North Dakota	0.2300	0.2300	0.2300	0.2300
Ohio	0.2800	0.2800	0.2800	0.2800
Oklahoma	0.1700	0.1700	0.1400	0.1700

(Continued next page)

Table O.38 **(continued)**

State	*Petrol*	*Gasohol (E10)*[b]	*Diesel*	*LPG*
	US$/gallon	US$/gallon	US$/gallon	US$/gallon
Oregon	0.2400	0.2400	0.2400	0.1850
Pennsylvania	0.3120	0.3120	0.3810	0.2280
Rhode Island	0.3200	0.3200	0.3200	0.3200
South Carolina	0.1600	0.1600	0.1600	0.1600
South Dakota	0.2200	0.0800	0.2200	0.2000
Tennessee	0.2000	0.2000	0.1700	0.1400
Texas	0.2000	0.2000	0.2000	0.1500
Utah	0.2450	0.2450	0.2450	0.2450
Vermont	0.2000	–	0.2900	–
Virginia	0.1750	0.1750	0.1750	0.1750
Washington	0.3750	0.3750	0.3750	0.3750
West Virginia	0.3220	0.3220	0.3220	0.3220
Wisconsin	0.3090	0.3090	0.3090	0.2260
Wyoming	0.1400	0.1400	0.1400	0.1400
US average [c]	0.2074	0.2627	0.2147	0.0985

a The table includes only state-wide volumetric taxes, such as excise, environmental taxes, special taxes and inspection fees. **b** 'Gasohol' is a mixture of petrol and ethanol that comprises 10 per cent ethanol. **c** Average weighted by sales volumes, and as reported by FHWA (US) (2011b). **–** Nil or rounded to zero. **..** Not applicable.

Source: FHWA (US) (2011b).

P Country stocktakes

This appendix provides the stocktake of emissions-reduction policies identified by the Productivity Commission in each study country (in separate tabs of this worksheet). The approach used to compile the stocktake is outlined in chapter 2. The sources used to provide information on individual policy measures are provided in the References column for each country.

Australia

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Explicit carbon prices					
Emissions trading scheme - baseline and credit	State	NSW Greenhouse Gas Reduction Scheme (GGAS)	Electricity retailers must meet mandatory emissions-reduction targets that are based on their market share, and must develop and encourage activities that offset emissions. Scheme participants must purchase NSW Greenhouse Abatement Certificates to meet their benchmark — each certificate represents a one tonne reduction in CO_2 emissions.	Commenced January 2003. In December 2006, the Electricity Supply Act 1995 (NSW) was amended to enable GGAS to be terminated if NSW participates in a national emissions trading scheme that will achieve greenhouse outcomes at least as stringent as those of GGAS.	http://www.ipart.nsw.gov.au/files/Final%20Report%20-%20Review%20of%20NSW%20Climate%20Change%20Mitigation%20Measures%20-%20Volume%202%20-%20May%202009%20-%20WEBSITE%20APD.PDF http://www.environment.nsw.gov.au/climateChange/ipartreview.htm
	State	ACT Greenhouse Gas Abatement Scheme	Mirrors the NSW Greenhouse Gas Reduction Scheme. The NSW and ACT schemes are, in many respects, operated as a single scheme. Under this arrangement, the NSW Independent Pricing and Regulatory Tribunal administers the overall scheme and accredits abatement projects, while the ACT Independent Competition and Regulatory Commission is the compliance regulator of the Scheme in the ACT.	Commenced January 2005.	http://www.icrc.act.gov.au/actgreenhousegasabatementscheme/overviewoftheactscheme
Emissions trading scheme - voluntary	Commonwealth	Indigenous Emissions Trading	Initiative to facilitate Indigenous participation in carbon markets by raising awareness, building capacity and funding research to improve scientific knowledge about Indigenous land management practices. Its focus is on generating carbon market opportunities through traditional fire management.	Commenced 2008-09. Due to end 2011-12.	http://www.fahcsia.gov.au/about/publicationsarticles/corp/BudgetPAES/budget2008-09/IndigenousFactSheets/Pages/ClosingGapIndigAusIndigEmissionFS30.aspx
Subsidies and taxes					
Capital subsidy	State	Energy Efficiency for Small Business Program (NSW)	Subsidised audits to identify energy savings, for up to 6000 small to medium businesses (SMEs), and rebates to assist emissions-reduction measures such as lighting upgrades and improvements to air conditioning and refrigeration.	Commenced 2008-09. Funded to 30 June 2011.	http://www.environment.nsw.gov.au/sustainbus/smallbusenergy.htm http://www.ipart.nsw.gov.au/files/Final%20Report%20-%20Review%20of%20NSW%20Climate%20Change%20Mitigation%20Measures%20-%20Volume%202%20-%20May%202009%20-%20WEBSITE%20APD.PDF
	State	Solar Hot Water Rebate Program (Victoria)	Rebates of $300 to $1500 for replacing existing water heaters with solar systems ($400 to $1600 in regional Victoria), depending on system size and performance. This program has an overall budget of $50 million.	Commenced July 2008 for 3 years.	http://www.resourcesmart.vic.gov.au/rebates
	State	Smart Energy Savings Program (Queensland)	Support for energy efficiency measures by Queensland businesses to fund buildings, appliances and industrial processes, through grants and loans where projects cannot be funded internally or attract traditional funding sources.		http://www.thepremier.qld.gov.au/library/pdf/initiatives/climate_change/ClimateSmart_2050.pdf
	State	Carbon Down (Victoria)	Program to encourage and enable Victorian SMEs to undertake actions that reduce greenhouse gas emissions through information sharing and funding.	Commenced 2008. Concludes June 2011.	www.carbondown.com.au
	State	Hardship Efficiency Program (WA)	An assistance program to help people in hardship to increase energy efficiency within their home through a combination of energy smart advice, education, and appliance upgrades. The program funds household energy efficiency assessments, a public and community housing sub program and special projects. $6 million is available for the program in 2010-2011.	Commenced late 2008. Ongoing.	http://www.energy.wa.gov.au/3/3626/64/hardship_efficiency_program.pm
	State	Climate Change Minor Works Program (Tasmania)	Schools can apply for funding assistance to undertake small capital projects to address efficiency and climate change concerns. This program has an overall budget of $750 000.		http://www.earnyourstars.tas.gov.au/__data/assets/pdf_file/0014/122414/FINAL_Tas_Govt_Agencies_Report_on_Climate_Change_2008-09.pdf

Policy type	Jurisdiction	Name	Description	Status and duration	References
	State	Home Power Savings Program (NSW)	Provides assistance to eligible low-income households across NSW to save power, reduce emissions, and lower utility bills through free in-home energy assessments by energy experts. Each household also receives an energy savings action plan. $63 million has been budgeted for this program.	Pilots conducted in 2008-09. State wide rollout commenced in May 2010. Program expected to finish June 2013.	http://www.savepower.nsw.gov.au/freehelp
	State	Climate Smart Homes Service (Queensland)	Funding to assist householders with tools to monitor and reduce their energy use.	Runs from 2008-09 to 2010-11.	http://www.climatesmarthome.com/faq.html
	State	Energy Choices Program (including Residential Gas Installation Rebate and EnergyWise Program) (Victoria)	The program includes residential gas installation rebates, energy audit service, school energy efficiency action plans and an EnergyWise off-peak campaign. This program has an overall budget of $33.1 million.	Commenced 2008-09.	http://www.budget.vic.gov.au/domino/Web_Notes/budgets/budget08.nsf/d6e571e551bef80eca2572bb002bcea7/72fb38265784d63eca257440003ed174!OpenDocument
	State	Energy Smart Households Program (NT)	Rebates for households of 50 per cent (up to $200) off the purchase and/or installation price of selected energy saving devices. Items available for rebate include power boards, energy efficient light globes, timers, power usage meters and fridge and freezer seals.	Anticipated to finish end of 2011.	http://www.nt.gov.au/nreta/environment/rebates/energysmart/
	State	Solar hot water rebates (SA)	A rebate of $500 for low income owner-occupiers on the cost of a new solar or electric heat pump water heater system installed on or after 1 July 2008.	Commenced 2001-02. Planned finish date June 2013.	http://www.energy.sa.gov.au/rebates_and_grants/solar_hot_water
	State	NSW Home Saver Rebates	Rebates given to households for hot water systems, hot water circulators, rainwater tanks, dual flush toilets and the removal of inefficient second fridges. Rebates for ceiling insulation and washing machines ended on 30 June 2009. This program has an overall budget of $170 million.	Commenced July 2007 and ends 30 June 2011.	http://www.environment.nsw.gov.au/grants/ccfund.htm http://www.environment.nsw.gov.au/rebates/index.htm
	State	Solar Water Heater Subsidy (WA)	Rebates of $500 for natural gas-boosted solar water heaters ($700 for bottled liquid petroleum gas-boosted solar hot water heaters in areas without reticulated gas). $6 million has been budgeted for the continuation of this program between 2010-11 and 2012-13.	Extended until June 2013.	http://www.dtf.wa.gov.au/cms/uploadedFiles/_Treasury/State_finances/myr_200910.pdf http://www.energy.wa.gov.au/2/3579/64/solar_water_heater_subsidy_scheme.pm
	State	Clean Energy Strategy for isolated and remote communities (Queensland)	Energy conservation, community engagement and renewable energy initiatives to reduce the amount of diesel fuel required for electricity generation in Queensland's 33 isolated network communities.		http://www.climatechange.qld.gov.au/pdf/factsheets/1energy-b2.pdf
	Commonwealth	Australian Carbon Trust	The Trust manages two programs: - An Energy Efficiency Program to provide finance and advice to eligible businesses and the public sector for the retrofit of commercial properties - The Carbon Neutral Program which provides accreditation for organisations.		http://www.climatechange.gov.au/government/initiatives/australian-carbon-trust.aspx
	Commonwealth	Renewable Energy Bonus Scheme	Eligible households can claim a rebate of $1000 for a solar hot water system or $600 for a heat pump hot water system. This rebate applies for systems ordered and purchased from February 2010.	Commenced February 2010.	http://www.climatechange.gov.au/government/programs-and-rebates/solar-hot-water.aspx
	Commonwealth	ACRE Solar Projects	The ACRE Solar Projects were originally applied for under the REDP (see REDP program description). ACRE funds two projects to a total amount of $92 million to accelerate the commercialisation and deployment of two solar energy technologies for power generation in Australia. These are the $60 million SolarOasis 'Big Dish' project in Whyalla, SA, and the $32 million CS Energy Kogan Creek Solar Boost project in Queensland. The program provides grants for up to one third of the eligible expenditure on the project.	Funding commenced 2009-10 and is due to end 2013-14.	http://www.ret.gov.au/energy/energy%20programs/cei/acre/acresolarproject/Pages/ACRESolarProjects.aspx
	Commonwealth	Solar Cities Program	Subsidises specific solar and energy efficient technologies and their installation in residential and commercial buildings, to showcase market viability and energy efficiency gains. The program is also trialling smart metering and conducting energy pricing trials. The program aims to engage the community in demonstrating solar technologies while collecting data on their use and cost. Over the period 2007-08 to 2012-13, the budget for this program is $94 million.	Runs from 2007-08 to 2012-13.	http://www.climatechange.gov.au/government/programs-and-rebates/solar-cities/~/media/publications/solar-cities/solar-cities-guidelines.ashx http://www.finance.gov.au/publications/strategic-reviews/docs/Climate-Report.pdf

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	State	Solar Cities Program (NT component)	Joint program between the Commonwealth, the Northern Territory Government and other partners. The funding recorded here ($3.5 million) represents the Northern Territory Government's contribution to the Alice Springs Solar City, which is one of five solar cities in Australia. The Australian Government's Solar Cities Program is designed to demonstrate how solar power, smart meters, energy efficiency and new approaches to electricity pricing can combine to provide a sustainable energy future in urban locations.	Runs from 2004-05 to 2012-13.	http://newsroom.nt.gov.au/index.cfm?fuseaction=printRelease&ID=3184
	State	Kogan Creek Solar Boost Project (Queensland)	$98 million project incorporating solar thermal technology into CS Energy's Kogan Creek Power Station near Dalby in south west Queensland. The solar thermal addition is expected to increase the station's capacity by up to 44 megawatts under peak solar conditions.	Fully operational by June 2012.	http://www.brightthing.energy.qld.gov.au/useruploads/files/kogan_creek.pdf
	State	Energy Efficiency Skills Training Program (NSW)	Consists of three elements: 1. funding of short courses for key trades and professions; 2. professional development programs for VET trainers; and 3. higher education courses and professional development partnership projects with industry for implementing and evaluating energy efficiency. $20 million has been budgeted for 2009-10 to 2012-13.	Commenced July 2009. Funded to June 2013.	http://www.ipart.nsw.gov.au/files/Final%20Report%20-%20Review%20of%20NSW%20Climate%20Change%20Mitigation%20Measures%20-%20Volume%202%20-%20May%202009%20-%20WEBSITE%20APD.PDF
	State	Victorian Large Scale Solar Project	Funding of up to $100 million to develop a new large-scale solar power station in Victoria, with the aim of having the plant operating by 2015. The project is subject to matching funding from the Commonwealth.	Announced in March 2009. Preferred proposal announced in September 2010.	http://www.new.dpi.vic.gov.au/energy/projects-research-development/solar/vlssp
	State	Low Emissions Energy Development Fund (WA)	Funding ($30 million over five years) under the Climate Change Action Statement of May 2007 to provide financial incentives to support technological advances that cut greenhouse gas emissions.	Commenced 2008-09. Final funding round 2011-12.	http://www.dec.wa.gov.au/content/view/3550/2283/
	Commonwealth	Ethanol Production Grants	A subsidy of A$0.38/litre (2009-10) is provided to eligible ethanol producers to offset fuel excise. This subsidy is to be gradually phased out from December 2011 with the introduction of taxes based on the energy content of biofuels.	Commenced September 2002. Due to end November 2011.	http://www.ret.gov.au/resources/Documents/Alternative%20Fuels%20Programs/Listing%20of%20all%20EDP%20grantees.pdf http://www.ret.gov.au/resources/resources_programs/alternative_fuels_programs/ethanol_distribution_program/Pages/EthanolDistributionProgram.aspx
Feed-in tariff	State	Premium and Standard Feed-in Tariffs (Victoria)	A standard feed-in tariff is available to households, community organisations and small businesses generating up to 100 kilowatts of electricity from wind, solar, hydro and biomass sources. Victoria's premium feed-in tariff offers Victorians with small-scale solar photovoltaic systems of up to five kilowatts in size a guaranteed minimum credit of at least 60 cents per kilowatt hour for excess electricity fed back into the grid at any time of the day or year.	Premium tariff commenced November 2009. Available until November 2024 or until 100MW of installed capacity or until the cost of the scheme for households exceeds $10 (whichever occurs first).	http://new.dpi.vic.gov.au/energy/policy/greenhouse-challenge/feed-in-tariffs
	State	Solar Bonus Scheme (Queensland)	Owners of solar photovoltaic systems (up to 10 kW) are paid A$0.44/kWh for excess electricity exported to the grid.	Commenced July 2008.	http://www.cleanenergy.qld.gov.au/solar_bonus_scheme.cfm
	State	Solar Feed-in Tariffs (SA)	Owners of solar photovoltaic systems (up to 10 kW) are paid A$0.44/kWh for excess electricity exported to the grid.	Commenced July 2008. In 2010, the SA Government proposed changes to the scheme following the scheme's review. The scheme will end June 2028.	http://www.climatechange.sa.gov.au/index.php?page=sa-s-solar-feed-in-scheme http://www.aer.gov.au/content/item.phtml?itemId=729527&nodeId=2693bca8e666807bbb40afa43652bd27&fn=ETSA%20Utilities'%20Regulatory%20Proposal%202010-15.pdf

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	State	Feed-in Tariff Scheme (ACT)	Owners of solar photovoltaic systems (up to 30 kW) are paid A$0.40–A$0.50/kWh (depending on the time of year the system was installed) for all electricity generated.	Stage 1 commenced March 2009. Stage 2 commenced September 2010.	http://www.environment.act.gov.au/energy/fit
	State	Solar Bonus Scheme (NSW)	Owners of solar photovoltaic systems (up to 10 kW) are paid A$0.60/kWh or A$0.20/kWh for all electricity generated (depending on when the system was installed).	Tariff rates to be paid until December 2016.	http://www.industry.nsw.gov.au/energy/sustainable/renewable/solar/solar-scheme
	State	Feed-in Tariff (WA)	Owners of solar photovoltaic systems (up to 10 kW) are paid A$0.40/kWh for excess electricity exported to the grid.	Commenced August 2010. Ongoing.	http://www.energy.wa.gov.au/2/3574/64/feedin_tariff.pm
Tax rebate or credit	State	Payroll tax rebate (SA)	From July 2010, investors in new large-scale renewable energy projects receive a rebate on payroll tax paid for labour associated with direct on-site construction of new renewable energy projects. The revenues forgone are estimated to be $3.6 million in 2010-11, $0.5 million in 2011-12 and $1.6 million in each of 2012-13 and 2013-14.	A four year initiative, commencing 2010-11.	http://www.revenuesa.sa.gov.au/payrolltax/payroll_rebates.html#Energy
	State	Clean coal levy offset to liability for mining royalty (Queensland)	Under the Clean Coal Technology Special Agreement Act 2007 a levy is imposed on coal mining in Queensland to help fund State Government clean coal projects. This measure means that the levy charged on coal mining can be used as a deduction in determining coal mining royalty.	Commenced 2008-09.	
	Commonwealth	Luxury Car Tax Concession	The luxury car tax threshold is set higher for fuel efficient cars.	Ongoing.	
	State	Hybrid vehicle registration discounts (Victoria)	$100 discount on registration for hybrid vehicles.	First announced in 2007 as a $50 discount. Increased to $100 in 2010.	http://www.vicroads.vic.gov.au/Home/Registration/RenewCancelOrUpdateRegistration/ConcessionsAndDiscounts/HybridVehicleRegistrationDiscount.htm
	Commonwealth	Cleaner Fuels Grants Scheme	Provides a payment of A$0.38/litre (2009-10) to producers and importers of biodiesel and renewable diesel to offset the amount of fuel excise paid. This scheme is to be abolished in December 2011 with the introduction of taxes based on the energy content of biofuels.	Ends June 2015.	http://www.ato.gov.au/content/downloads/n9886-12-2005final.pdf
Tax exemption	Commonwealth	Tax Breaks for Green Buildings	From July 2011, businesses that invest in eligible assets or capital works to improve the energy efficiency of an existing building may be eligible to apply for a one-off bonus tax deduction under the Tax Breaks for Green Buildings Scheme.	Due to commence July 2012. Funding is intended to go out to 2018-19.	http://www.climatechange.gov.au/government/initiatives/tax-breaks-for-green-buildings.aspx
	Commonwealth	Tax deductible carbon sink forests	Immediate tax deduction available to businesses that plant a forest for the purpose of absorbing carbon dioxide from the atmosphere. $38 million has been budgeted for these deductions for the period 2008-09 to 2011-12.	Ongoing.	http://www.aph.gov.au/library/pubs/climatechange/responses/economic/tax.htm http://www.finance.gov.au/publications/strategic-reviews/docs/Climate-Report.pdf
Preferential, low-interest or guaranteed loan	Commonwealth	Green Loans Program	Provided free home sustainability assessments to households. Home sustainability assessments involved an assessor (trained and contracted by government) visiting the home and providing a report that identified ways to save energy and water. Based on the outcomes of the assessment, households may have been eligible for government funding or loans. Up until May 2010, households could claim back up to $50 in small items as part of the Green Loans - Green Rewards program. For larger items, such as solar panels and rainwater tanks, Green Loans were available. Green Loans were provided to eligible households to fund the purchase and installation of eligible items recommended in the assessment report.	Commenced 2008-09. Ended February 2011.	http://www.anao.gov.au/download.cfm?item_id=1D94462E1560A6E8AA8E11D02755BA60&binary_id=55C5DBE61560A6E8AAB2E521525EDF12 http://www.climatechange.gov.au/government/programs-and-rebates/green-loans.aspx
			Loans of up to $10 000 were provided by participating financial institutions, interest-free for the first four years. The government provided the financial institutions an interest subsidy and a $200 administration fee for each loan provided. This component of the program ceased February 2011. Over the period 2008-09 to 2010-11, the fiscal cost (cost to government) of this program was $277 million.		

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Other subsidy or grant	State	Biofuels Infrastructure Grants Program (Victoria)	Provides $5 million in grants to assist in the development of infrastructure necessary for the production and distribution of biofuels.	Commenced.	http://www.business.vic.gov.au/BUSVIC/GAP/1001/PC_63282.html,svGAP_PC=PC_61480,contextPC=PC_61480,svgapkeep=Y,.CKB
	State	Energy Technology Innovation Strategy (ETIS) funding for pre-commercial large scale demonstration projects (Victoria)	$50 million HRL (Dual Gas) 600MW demonstration power generation plant to demonstrate a Victorian owned and developed integrated drying, gasification combined cycle technology and $30 million for a large scale brown coal drying demonstration at Hazelwood Power Station (Hazelwood 2030 project) and a pilot carbon capture plant.	HRL Dual Gas project is progressing (works approval is currently being considered by EPA, however the project has been delayed by carbon price uncertainty). The Hazelwood carbon capture pilot was commissioned in July 2009, however, the major coal drying component is being terminated due to technical failure and cost pressures.	http://www.new.dpi.vic.gov.au/energy/projects-research-development/etis
	State	Funding for solar power electricity generation project (Victoria)	Funding of up to $50 million for a 154MW solar power electricity generation plant to be built by Silex Systems Generation in North-West Victoria.	Construction of 2 MW pilot (precursor to a full scale plant) to be completed in 2011.	http://www.new.dpi.vic.gov.au/energy/projects-research-development/etis
	State	Building Innovation Fund (SA)	A four year project to improve the performance of commercial buildings through capital works grants and feasibility studies related to upgrading buildings to reduce greenhouse gas emissions. This project has an overall budget of $2 million.	Two rounds have been completed. Round three of the program has been announced and will close March 2011.	http://www.climatechange.sa.gov.au/index.php?page=building-innovation-fund
	State	Water and Energy Efficiency Initiative (Victoria)	Funding to regional industry to implement energy efficiency measures. This initiative has an overall budget of $10 million.		http://www.business.vic.gov.au/BUSVIC/STANDARD/1001/PC_63858.html
	State	FreightSmart (Queensland)	Program to investigate ways of streamlining freight deliveries to reduce urban congestion and greenhouse gas emissions. Grants of up to $50 000 will be provided to industry to examine and test innovative logistics approaches, such as off peak freight deliveries.		http://www.climatechange.qld.gov.au/pdf/factsheets/6transport-n8.pdf
	State	Community Solar Farms (Queensland)	Grants for community-owned and operated solar farms.	Announced in December 2010. Committed.	
	State	Environment Grants (NT)	Grants available to individuals, community groups, local government and industry associations for environmental projects and education activities in the Territory.	Commenced 2004-05. Ongoing.	http://www.nt.gov.au/nreta/environment/grants/overview.html
	State	EcoBiz NT	Energy audits and grants available to eligible businesses and projects to assist in implementing energy efficiency measures. Grants of 50 per cent of eligible expenditure up to a maximum of $20 000 are available. Total funding from 2008-09 to 2010-11 amounts to $2.04 million.	Runs from 2008-09 to 2010-11. Funding ends June 2011.	http://www.ecobiznt.nt.gov.au/index.shtml
	Commonwealth	Green Precincts Program	Provides matching funding between $500 000 and $1.5 million, for up to 50 per cent of the costs to deliver high profile energy and water savings projects that demonstrate their achievements to the community. $6.2 million has been budgeted for the period 2008-09 to 2011-12.	Commenced 2008-09. Funding provided for four years. All projects are due for completion by June 2012.	http://www.finance.gov.au/publications/strategic-reviews/docs/Climate-Report.pdf
	Commonwealth	National Solar Schools Program	Grants of up to $50 000 for single campus schools and up to $100 000 for eligible multi-campus schools to install solar power systems, rainwater tanks and a range of renewable energy and energy efficiency measures. Over the period 2007-08 to 2014-15, the budgeted cost for this program is $422 million.	Commenced 2007-08 and scheduled to finish in 2014-15.	http://www.climatechange.gov.au/government/initiatives.aspx?mode=qrst&page=2&filter=

Policy type	Jurisdiction	Name	Description	Status and duration	References
	State	Solar Schools Program (WA)	Provides up to $12 500 for metropolitan schools (up to $13 000 for regional schools), above a minimum school contribution of $1000, for new solar systems and additions to existing ones. $7.5 million has been budgeted for the period 2010-11 to 2011-12.	Extended to 2011-12.	http://portal.environment.wa.gov.au/pls/portal/docs/PAGE/DOE_ADMIN/GREENHOUSE_REPOSITORY/TAB6327544/2007006CLIMATECHANGE.PDF http://www.energy.wa.gov.au/2/3417/64/wa_solar_schools_program.pm
	State	ClimateConnect Grants Program (Tasmania)	Incorporated and not-for-profit community organisations are eligible for grants of up to $30 000 for projects that encourage people to work together to reduce emissions or conserve energy. Climate Connect funding of $159 208 and Micro-grant funding of $22 122 were awarded in 2009-10.	Runs from 2008-09 to 2010-11.	http://www.earnyourstars.tas.gov.au/grants/climateconnect_grants/program_overview
	Commonwealth	Climate Ready Program (part of Clean Business Australia Initiative)	Four year $78.5 million program providing grants of $50 000 to $5 million on a matching funding basis to support SMEs in the development and commercialisation of innovative products, processes and services that address the effects of climate change. The program provides support for research and development (R&D), proof-of-concept and early-stage commercialisation activities.	Commenced 2008-09. Scheduled to end in 2012-13.	http://www.ausindustry.gov.au/InnovationandRandD/ClimateReadyProgram/Documents/Climate%20Ready%20Fact%20Sheet.pdf
	State	Environmental Enhancement Fund (NT)	Provides grants to tourism operators to assist them in improving their environmental performance through a wide range of measures, including energy reduction.	Commenced in 2009-10 and is funded until the end of 2010-11.	http://www.tourismnt.com.au/Portals/3/docs/industry/green/Enviro-Enhancement-Fund-App-Sept10%20.pdf
	Commonwealth	Re-tooling for Climate Change (part of Clean Business Australia initiative)	Provides grants to small and medium sized Australian manufacturers to help them reduce their environmental footprint, through projects that improve the energy and/or water efficiency of their production processes. The program provides grants between $10 000 and $500 000, up to a maximum of half the cost of each project.	Commenced 2008-09. Closed to new applicants.	http://www.ausindustry.gov.au/InnovationandRandD/Re-toolingforClimateChange/Pages/Re-toolingforClimateChange.aspx
	Commonwealth	Green Building Fund (part of Clean Business Australia initiative)	Six year $120 million program providing grants ranging from $50 000 to $500 000, up to 50 per cent of eligible project costs, to reduce greenhouse gas emissions through the retrofitting and retro-commissioning of existing Australian commercial office buildings. The Fund also provides grants of up to 50 per cent of eligible project costs, to a maximum of $200 000, to improve the skills and capability of those involved in the operation of commercial office buildings in order to improve energy efficiency and reduce emissions. From 2010, the Fund has been expanded with an additional $30 million to widen its scope and include hotels and shopping centres.	Commenced 2008-09. Scheduled to end in 2013-14.	http://www.ausindustry.gov.au/InnovationandRandD/ClimateReadyProgram/Documents/Climate%20Ready%20Fact%20Sheet.pdf
	Commonwealth	Green Car Innovation Fund	Grants to support the design, development and commercialisation of low-emission fuel-efficient cars, components and technologies in Australia.	Commenced 2009-10. Closed January 2011.	http://www.ausindustry.gov.au/Manufacturing/GreenCarInnovationFund/Pages/GreenCarInnovationFund(GCIF).aspx
	State	Solar Sport and Community Groups Grants (Queensland)	$10 million over three years to support eligible not-for-profit sporting and community organisations purchasing solar technologies.	Commenced in 2010.	http://brightthing.energy.qld.gov.au/rebate-and-incentives/solar-sports-communities-grant/
	Commonwealth	Low Emissions Technology Demonstration Fund (LETDF)	Funding for Australian firms to demonstrate the commercial potential of new energy technologies or processes, or the application of overseas technologies or processes to Australian circumstances. There will be no further application rounds under the LETDF, though funded projects will continue. $335 million has been committed to the LETDF.	Funding commenced 2004-05 and is due to end in 2014-15.	http://www.ret.gov.au/energy/Documents/energy%20programs/letdf-round-1-funded-projects.pdf
	Commonwealth	Low Carbon Communities	Funding of $80 million over four years to support local councils and community groups to cut pollution and reduce their energy costs through energy efficiency upgrades to street lighting, community facilities and council buildings.	First call for applications for funding expected in mid-2011.	http://www.climatechange.gov.au/government/initiatives/low-carbon-communities.aspx

Policy type	Jurisdiction	Name	Description	Status and duration	References
	Commonwealth	Renewable Energy Demonstration Program (REDP)	A $235 million competitive grants program designed to accelerate the commercialisation and deployment of new renewable energy technologies for power generation in Australia. The program provides grants for eligible renewable energy power generation demonstration projects, of up to one third of the eligible expenditure on the project. The size of grants range from $15 million to $90 million.	Runs from 2007-08 to 2014-15.	http://www.ret.gov.au/energy/Documents/Renewable%20Energy%20Demonstration%20Program/REDP%20FactSheet%20PDF.pdf
	Commonwealth	Geothermal Drilling Program	Provides assistance to companies seeking to develop geothermal energy with the cost of proof-of-concept projects including drilling geothermal wells. Grants are $7 million for each recipient.	Runs from 2008-09 to 2014-15.	http://www.ret.gov.au/energy/energy%20programs/cei/acre/gdp/Pages/default.aspx
	State	Grants for geothermal energy exploration and precompetitive proof-of-concept (SA)	Targeted grants for co-funded (by industry) precompetitive geothermal energy research.	Commenced 2005-06. Ongoing.	
	Commonwealth	Second Generation Biofuels Research and Development Program	Supports the research, development and demonstration of new biofuel technologies and feedstocks that address the sustainable development of a biofuels industry in Australia.	Commenced 2008-09.	http://www.ret.gov.au/resources/resources_programs/alternative_fuels_programs/second_generation_biofuels_research_and_development_program/Pages/SecondGenerationBiofuelsResearchandDevelopmentProgram.aspx
	State	Public Facilities Program (NSW)	Provides $30 million in funding for energy and water saving projects in facilities which are open to, and frequently accessed by, the public, including schools, community buildings, sporting facilities, museums and art galleries. This program includes grants of up to $440 000 for not-for-profit community groups under the Community Savers Stream.	Runs from 2007 to 2012. The demonstration stream closed 2009-10.	http://www.environment.nsw.gov.au/grants/ccfpfp.htm http://www.ipart.nsw.gov.au/files/Final%20Report%20-%20Review%20of%20NSW%20Climate%20Change%20Mitigation%20Measures%20-%20Volume%202%20-%20May%202009%20-%20WEBSITE%20APD.PDF
	State	Renewable Energy Development Program (NSW)	Aimed at stimulating investment in the development or commercialisation of new renewable energy technologies that will generate electricity or displace grid electricity use in NSW for stationary energy purposes, and consequently result in reduced greenhouse gas emissions. The program has an overall budget of $40 million.	Runs from 2007 to 2012.	http://www.environment.nsw.gov.au/grants/ccfred.htm http://www.ipart.nsw.gov.au/files/Final%20Report%20-%20Review%20of%20NSW%20Climate%20Change%20Mitigation%20Measures%20-%20Volume%202%20-%20May%202009%20-%20WEBSITE%20APD.PDF
	State	Funding for large scale sustainable energy demonstration projects (Victoria)	$72 million announced in 2008. The Geelong Geothermal Power project was granted provisional funding of $25 million (also offered $7 million from the Commonwealth's Geothermal Drilling Program). $30 million was redirected to SERD 2 and SEPD 1 (see below).	Geothermal project announced December 2009. Contract not yet signed.	http://new.dpi.vic.gov.au/earth-resources/industries/?a=8004 http://www.greenearthenergy.com.au/projects/
	State	ETIS funding for large-scale, pre-commercial Carbon Capture Storage demonstration projects (Victoria)	$110 million announced April 2008. This funding is the first stage of the CarbonNet project. The CarbonNet Project (CarbonNet) is investigating the feasibility of a large-scale demonstration network for carbon capture and storage to assist Victoria move to a cleaner energy future.	Five successful projects were announced in November 2009 to proceed to develop prefeasibility studies. One project has since withdrawn. Results and further announcements are expected by the end of 2011.	http://new.dpi.vic.gov.au/earth-resources/industries/?a=8004

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	State	ETIS Sustainable Energy Pilot Demonstration Program (SEPD 1) (Victoria)	$20 million for sustainable energy (renewables and energy efficiency) at pilot demonstration stage. $5.1 million rolled in from SERD2. Includes $4.2 million from the Latrobe Valley Advantage Fund.	Commenced with EoI in 2010. RFP to be released to selected proponents February 2011. Successful projects to be announced in mid 2011.	http://new.dpi.vic.gov.au/earth-resources/industries/?a=8004
	State	ETIS Sustainable Energy Research and Development Program (SERD 2) (Victoria)	$10 million for developing new technologies in sustainable energy at the R&D stage.	Projects likely to be completed by 2014.	http://new.dpi.vic.gov.au/earth-resources/industries/?a=8004
	State	Tourism Electricity Support Program (NT)	Provides grants to qualifying applicants to fund electricity infrastructure outside the Territory's major regional centres. Priority is placed on applications that incorporate renewable energy generation systems or other energy efficiency initiatives.	Ongoing.	
	State	ResourceSmart Buildings - Commercial (Victoria)	Aimed at improving the environmental performance of commercial buildings.		http://www.resourcesmart.vic.gov.au/for_businesses/buildings_2098.html
	State	Solar Kindergartens (Queensland)	Installation of solar photovoltaic systems on up to 420 new and existing kindergarten buildings constructed or extended over the next four years. The budget for this program is $5.76 million.	Commenced 2010.	http://education.qld.gov.au/infrastructure/solarkindy/doc/solar-kindy-guidelines.doc
Fuel or resource tax	National	Fuel excises	Australia levies excise on petrol, diesel and most biofuels at the rate of A$0.38/litre (with rebates for off road use), but does not currently tax liquefied petroleum gas (LPG) or other gaseous transport fuels (changes to these arrangements are scheduled to take effect from December 2011).	Ongoing.	Australian Taxation Office
Other tax	State	Differential stamp duty by number of cylinders (Queensland)	Graduated scale for motor vehicle transfer duty based on the number of cylinders (vehicles with more cylinders are charged more). The lowest stamp duty rates are for hybrid and electric vehicles.	Commenced January 2008.	http://www.cabinet.qld.gov.au/MMS/StatementDisplaySingle.aspx?id=52110
	State	Green Vehicle Duty Scheme (ACT)	Stamp duty for purchased or transferred motor vehicles is based on a graduated scale reflecting the value of the car and the Green Vehicle rating achieved. The Green Vehicle Rating rates new vehicles for environmental performance according to air pollution and greenhouse gas emissions. For vehicles with a rating of 16 or above, no stamp duty is payable.	Commenced September 2008.	http://www.revenue.act.gov.au/duties/motor_vehicles
Regulatory instruments					
Renewable energy target	State	SA Renewable Energy Target	Establishment of the State's Renewable energy production and consumption target. The target is to support the development of renewable energy so that it comprises 20 per cent of South Australia's electricity production and consumption by December 2014. In 2009, the Premier announced plans to increase South Australia's renewable energy production target to 33 per cent by 2020.	As defined by the targets.	http://www.climatechange.sa.gov.au/index.php?page=renewable-energy-in-sa
Renewable energy certificate scheme	Commonwealth	Large-scale Renewable Energy Target (LRET)	Wholesale purchasers of electricity (retailers and large users) are required to purchase large-scale renewable energy certificates (RECs) to achieve annual targets for the overall amount of renewable energy generation. Annual targets increase over time from an initial level of 10 400 GWh of large scale renewable energy in 2011. Between 2020 and 2030 the annual target is 41 000 GWh.	Commenced January 2011. Scheme extends until 2030.	http://www.orer.gov.au/publications/pubs/LRET-SRES-the%20basics%200111.pdf
	Commonwealth	Small-scale Renewable Energy Scheme (SRES)	Electricity retailers are required to purchase a certain number of RECs from owners of eligible small-scale renewable energy installations (such as micro generation, heat pumps and solar water heaters). The scheme does not have an overall general target and the small-scale technology percentage required to be purchased is set each year.	Commenced January 2011. Scheme extends until 2030.	http://www.orer.gov.au/publications/pubs/LRET-SRES-the%20basics%200111.pdf

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Electricity supply or pricing regulation	State	Clause 45B of the Electricity Supply (General) Regulation - Renewable energy requirement (NSW)	Under the Electricity Supply (General) Regulation 2001, all electricity suppliers that supply or offer to supply electricity to residential premises are required, as a condition of licence, to make an offer to each potential new or moving customer that the equivalent of a minimum of 10 per cent of their electricity will be obtained from accredited renewable energy sources. The conditions aim to encourage household support for renewable energy.	Commenced January 2007.	http://www.ipart.nsw.gov.au/files/Final%20Report%20-%20Review%20of%20NSW%20Climate%20Change%20Mitigation%20Measures%20-%20Volume%202%20-%20May%202009%20-%20WEBSITE%20APD.PDF
	State	GreenPower Offer Requirement - Utilities (Electricity Retail) Licence Conditions Direction 2009 (ACT)	Requirement on electricity suppliers that GreenPower be offered to all new electricity customers.	Commenced April 2009.	http://www.icrc.act.gov.au/__data/assets/pdf_file/0008/142289/GreenPower_Direction_DI2009-21.pdf
	Commonwealth	A Cleaner Future for Power Stations	This program aims to implement an Emissions and Carbon Capture and Storage Ready Standard for new coal-fired power stations. It will also require all existing generation plants, including coal-fired power stations, to participate in the Energy Efficiency Opportunities program and enforce stricter greenhouse gas emission reporting requirements on all electricity generating facilities.	Election commitment but yet to be implemented. The objective is to implement this program in 2011.	http://www.ret.gov.au/energy/sustainability_and_climate_change/domestic_climate_change/cfps/Pages/a-cleaner-future-for-power-stations.aspx
	Commonwealth	GreenPower Accreditation Program	National accreditation program for products offered by energy providers and responsible for setting environmental and reporting standards.	Commenced in 1997, ongoing.	http://www.greenpower.gov.au/for-generators-and-retailers.aspx
	State	Queensland Gas Scheme	Electricity retailers must source a minimum percentage of their electricity from eligible gas-fired electricity. Requirements must be met by surrendering Gas Electricity Certificates that are created for each MWh of electricity produced by eligible gas generators. The mandatory target was 15 per cent of generation in 2010 and will rise to 18 per cent by 2020.	Commenced 2000.	http://www.energyfutures.qld.gov.au/queensland_gas_scheme.cfm
Technology standard	Commonwealth	CO_2 Emissions Standards for Light Vehicles	Introduction of mandatory CO_2 emissions standards for all four wheeled light road vehicles under 3.5 tonnes from 2015.	Election commitment but yet to be implemented. Consultation process has commenced.	
Fuel content mandate	State	NSW Biofuels Mandate	Under the Biofuel (Ethanol Content) Act 2007, primary wholesalers of petrol are required to ensure that ethanol sales (in petrol-ethanol blends) comprise no less than 2% of the total volume of petrol they sell (including petrol-ethanol blends). The Biofuel (Ethanol Content) Amendment Act 2009 included a range of amendments which increase support for biofuels. The volumetric ethanol mandate was increased to 4% from 1 January 2010 and to 6% from 1 January 2011. From 1 July 2011, it requires all regular unleaded petrol to be replaced by E10 (10% ethanol). It also establishes a volumetric biodiesel mandate of 2% (later changed to commence 1 January 2010), increasing to 5% from 1 January 2012. On 2 December 2010, due to a shortage of ethanol, the increase in volumetric ethanol content to 6% was deferred to 1 July 2011 and the replacement of petrol with E10 deferred to 1 July 2012. Capital investment by fuel distributors amount to $9.5 million and Departmental administration costs were $176 000 in 2007-08 and $82 000 in 2008-09.	Commenced October 2007. Ongoing.	http://www.ipart.nsw.gov.au/files/Final%20Report%20-%20Review%20of%20NSW%20Climate%20Change%20Mitigation%20Measures%20-%20Volume%202%20-%20May%202009%20-%20WEBSITE%20APD.PDF http://www.biofuels.nsw.gov.au/
Energy efficiency regulation	State	Energy efficiency licence conditions on gas suppliers (NSW)	Under the Gas Supply Act 1996, gas suppliers distributing more than 100 terajoules of natural gas a year are required to prepare a three year plan to promote the adoption of thermally efficient gas appliances and efficient energy-use practices, plus preparing and publishing an annual report on the plan's implementation.	Commenced in 1996. IPART has not enforced compliance with this clause since 2002-03 and has reported on this matter in its recent annual reports on compliance by energy licence holders.	http://www.ipart.nsw.gov.au/files/Final%20Report%20-%20Review%20of%20NSW%20Climate%20Change%20Mitigation%20Measures%20-%20Volume%202%20-%20May%202009%20-%20WEBSITE%20APD.PDF
	State	Residential water heater installation requirements (SA)	From 1 July 2008, water heaters installed in new or established dwellings need to meet performance requirements that increase the proportion of low emissions/high efficiency water heaters and water efficient showerheads.	Commenced July 2008.	http://www.energy.sa.gov.au/__data/assets/pdf_file/0013/23350/HWS_Discussion_Paper.pdf

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	State	Electric hot water system phase out (Queensland)	Existing houses and townhouses located in a gas reticulated area are required to install a greenhouse efficient hot water system (that is, a gas, solar or heat-pump system) when their existing electric system needs replacing.	Commenced January 2010 but is currently on hold due to flood reconstruction priorities.	http://www.dip.qld.gov.au/sustainable-housing/electric-hot-water-system-replacement.html
	State	Ban of electric hot water systems in new homes (Queensland)	New houses (not units) are required to install a greenhouse-efficient hot water system - gas, solar or heat pump.	Commenced March 2006.	http://www.dip.qld.gov.au/sustainable-housing/electric-hot-water-system-replacement.html
	Intergovernmental	Minimum Energy Performance Standards (MEPS)	Prescribes minimum energy use standards for specific types of major energy-using devices in the residential, commercial and industrial sector. This program was introduced in 1999. This is a cross jurisdictional program under the National Framework for Energy Efficiency and coordinated by the Department of Climate Change and Energy Efficiency. This program is linked to the mandatory energy efficiency labelling program.	Commenced October 1999 for some products. New products are continually added. Ongoing.	http://www.energyrating.gov.au/man1.html
	State	Improving the energy efficiency of air conditioning systems (SA)	A package of voluntary and regulatory measures to improve energy efficiency standards for air conditioners.	Commenced January 2010.	http://www.dtei.sa.gov.au/energy/government_programs/energy_efficiency_requirements_for_air_conditioners/measures_to_better_manage_south_australias_air_conditioner_energy_use http://www.dtei.sa.gov.au/energy/government_programs/energy_efficiency_requirements_for_air_conditioners
	State	6-star houses and townhouses (Queensland)	New houses and townhouses, and major renovations to these buildings, must achieve a minimum 6-star energy equivalence rating.	Commenced May 2010.	http://www.dip.qld.gov.au/sustainable-housing/6-star-energy-rating.html
	State	6-star energy efficiency requirements for new buildings and major renovations (SA)	As part of COAG's National Strategy on Energy Efficiency, the energy efficiency requirements for new and renovated commercial and residential buildings were strengthened. This includes a 6 star level of energy efficiency for houses to be implemented by May 2011.	The energy efficiency requirements in the Building Code of Australia were adopted in South Australia from September 2010. Because of the difficulty in adjusting transportable houses to meet 6 stars, this sector of the industry have been given a concession.	
	State	5-star Plus Program (WA)	Energy and water efficiency standards for new housing in Western Australia. Introduced on September 2007 and mandatory from September 2008. Main requirements are for low greenhouse emitting hot water systems, water efficient fixtures (taps, toilets and showerheads), and blankets for pools and spas.	Ongoing. WA has adopted BCA 2010 6 star thermal energy efficiency provisions for all new houses from May 2011. However, a transition period of 12 months will be allowed so that the 6 Star implementation will not be mandatory until May 2012. WA has also adopted BCA 2010 provisions for hot water systems (replacing the 5 Star Plus hot water system requirements) and energy efficient lighting. WA adopted increased energy efficiency provisions for commercial buildings from May 2010, subject to the same 12-month transition period.	http://www.buildingcommission.wa.gov.au/bid/5StarPlus.aspx http://www.dec.wa.gov.au/component/option,com_docman/task,doc_download/gid,4341/Itemid,/

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	State	5-star rated units (Queensland)	New units and major renovations (for example, additions, alterations or relocations) must meet a 5-star energy equivalence rating under the Queensland Development Code (QDC) Mandatory Part (MP) 4.1—Sustainable buildings. The sole occupancy units within a class 2 (for example, multi-residential) building must collectively achieve an average energy equivalence rating of not less than 5-stars and individually achieve an energy equivalence rating of not less than 4-stars.	Commenced May 2010.	http://www.dip.qld.gov.au/sustainable-housing/5-star-energy-equivalence-ratings-for-units.html
	Commonwealth	Performance standards for buildings (Building Code of Australia)	From January 2003, the ABCB introduced energy efficiency standards into volume two of the Building Code, covering new house and additions to existing houses. From May 2006, energy efficiency provisions for detached and semi-detached dwellings increased to a nominal 5 star rating under the Nation-wide House Energy Rating Scheme (NatHERS).		http://www.climatechange.gov.au/what-you-need-to-know/buildings.aspx
	State	Ban the banners program (Queensland)	Amendment to the Building Act and other legislation to prevent covenants and by-laws set by residential estates and body corporates from banning energy efficient design features and fixtures. The amendments passed in 2009 but some have since been overturned.	Commenced 2010.	http://www.dip.qld.gov.au/resources/factsheet/sustainable-living/new-covenant-and-body-corporate-by-laws-factsheet.pdf http://www.propertyoz.com.au/qld/Article/NewsDetail.aspx?p=16&id=2756
	State	Minimum energy efficiency standard for air conditioners (Queensland)	From September 2010, new or replacement air conditioners installed in all new or existing buildings (classes 1-10) must have a minimum tested average Energy Efficiency Ratio of 2.9 or higher for cooling. This follows on from the ban on installing inefficient air conditioners in houses, townhouses and units (class 1 and 2 buildings) which has applied since September 2009.	Commenced September 2010. Some components commenced September 2009.	http://www.dip.qld.gov.au/resources/factsheet/sustainable-living/minimum-energy-rating-for-air-conditioners-fact-sheet.pdf
	State	Energy efficient lighting standards (Queensland)	New houses, townhouses and units must have energy efficient globes installed to a minimum of 80 per cent of the total fixed light fittings, including attached garages. This requirement was extended to also include balconies and decks from May 2010. Alternatively, houses and townhouses can adopt the minimum number of watts per square metre allowed under the energy efficient lighting section of the Building Code of Australia 2010.	Commenced 2009. Some components commenced in 2010.	http://www.dip.qld.gov.au/resources/factsheet/sustainable-living/energy-efficient-lighting.pdf
	State	Sustainability Declaration (Queensland)	A sustainability declaration is a compulsory checklist that must be completed by the seller (vendor) when selling a house, townhouse or unit. There is no need to engage a building professional to complete the form. The sustainability declaration identifies the property's environmental and social sustainability features in the areas of energy, water, access and safety.	Commenced January 2010.	http://www.dip.qld.gov.au/sustainable-housing/sustainability-declaration.html
	State	Building Sustainability Index (BASIX) (NSW)	State Environment Planning Policy requiring all new residential development to achieve energy and water savings targets of up to 40 per cent compared to pre-BASIX (2004) baseline. The Policy mandates energy and water savings targets as part of the development approval process for all new residential developments and renovations with a total or estimated cost of $50 000 or more and all new pools over 40 000L. All residential development applications require a BASIX Certificate. BASIX certificates are issued via an online program which allows builders and home owners to assess the most cost effective options to attain the required energy and water savings. BASIX administration or running costs up to 2009-10 are estimated at around $8.9 million.	Some elements commenced July 2004. Other components started later.	http://www.ipart.nsw.gov.au/files/Final%20Report%20-%20Review%20of%20NSW%20Climate%20Change%20Mitigation%20Measures%20-%20Volume%202%20-%20May%202009%20-%20WEBSITE%20APD.PDF
	State	5 star standard, residential buildings (Victoria)	Building regulation that requires all new homes to attain a 5 star energy rating and install a solar hot water service or a water tank.	Commenced 2005.	http://www.makeyourhomegreen.vic.gov.au/www/html/1962-introduction.asp?intLocationID=1960

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	State	Residential Design Code - strengthen greenhouse related actions (WA)	Provides a comprehensive basis for the control, through local government, of residential development throughout Western Australia. The Codes do not specify universal development provisions for climate sensitive design because conditions vary greatly from site to site. However, the Codes do provide broad guidance in achieving good design outcomes and variations based on regional climatic conditions. The Building Code of Australia provides specifications on the materials required to achieve energy efficiency of a building. The R-Codes are currently being reviewed and numerous issues will be considered, including sustainable development issues, promoting more energy efficient built forms and use of water sensitive design techniques.	The R-Codes are under review and it is anticipated that public consultation will be undertaken in May/June 2011, at which time comments on the proposed changes to the R-Codes can be submitted.	http://www.google.com.au/url?sa=t&source=web&cd=1&ved=0CB0QFjAA&url=http%3A%2F%2Fwww.dec.wa.gov.au%2Fcomponent%2Foption%2Ccom_docman%2Ftask%2Cdoc_download%2Fgid%2C4341%2FItemid%2C%2F&rct=j&q=complemtary%20review%20measures%20western&ei=fJkJTeLlLpT6sAO0xKSjCA&usg=AFQjCNHxRGVIUvctUF_VDIbFXbojTI2L8g
	State	Smart Energy Savings Program (Queensland)	Under the Clean Energy Act 2008, large energy using businesses (100-500 terajoules per annum) not registered or required to be registered under the Energy Efficiency Opportunities Act 2006 (Commonwealth) are required to undertake mandatory energy efficiency audits, development of energy savings plan and publication of their implementation.	Commenced 2008-09.	http://www.thepremier.qld.gov.au/library/pdf/initiatives/climate_change/ClimateSmart_2050.pdf
	State	Energy Saver Incentive Scheme (Victorian Energy Efficiency Target)	This scheme creates a legal liability for energy retailers (both electricity and gas) to meet a share of an annual greenhouse gas emissions reduction target, based on their proportional share of the markets, by providing households with energy saving products and services at little or no cost.	Commenced January 2009. This runs until January 2029 but may end earlier if a national ETS delivers lower cost greenhouse gas abatement.	http://new.dpi.vic.gov.au/energy/policy/efficiency
	State	Environment and Resource Efficiency Plans (Victoria)	Under the Environment Protection (Environment and Resource Efficiency Plans) Regulations 2007, commercial and industrial sites using more than 100 terajoules of energy or 120 megalitres of water per year are required to prepare and implement a plan that identifies actions with a three year or less payback period to reduce energy and water use, and waste generation.	Commenced 2008.	http://www.epa.vic.gov.au/bus/erep/EREP_delivers_savings.asp
	State	Savings Action Plans (NSW)	High energy and water users in NSW are required under the Energy and Utilities Administration Act 1987 to prepare Water and Energy Savings Actions Plans which provide a comprehensive analysis of an organisation's energy or water use and management strategies. To prepare a plan, energy and water users must determine current energy and water use, undertake a management review, undertake a detailed technical audit of their site and assess and identify savings measures. Sites with approved plans must submit annual reports on progress.	Program commenced in 2005-06, with Savings Action Plans approved in June 2009.	http://www.environment.nsw.gov.au/sustainbus/savingsactionplans.htm
	State	Residential Energy Efficiency Scheme (SA)	The scheme requires electricity and gas providers to deliver energy audits and energy efficiency measures to households, such as energy efficient lighting, water efficient showerheads, and ceiling insulation and draught proofing, with a certain proportion of measures delivered to low-income households. This scheme aims to improve residential sector energy efficiency and lower energy costs for households, particularly low income households.	Commenced January 2009. This runs until January 2029 but may end earlier if a national ETS delivers lower cost greenhouse gas abatement.	http://www.energy.sa.gov.au/government_programs/rees
	State	NSW Energy Savings Scheme (ESS)	A mandatory energy efficiency scheme for electricity retailers. Participating electricity retailers are required to meet individual energy savings targets based on the size of their share of the electricity market. Retailers meet energy savings targets by purchasing energy savings certificates from companies with recognised energy reductions.	Commenced February 2009. The Energy Saving Scheme will operate until 2020 unless replaced by a national energy efficiency trading scheme.	http://www.ipart.nsw.gov.au/files/Final%20Report%20-%20Review%20of%20NSW%20Climate%20Change%20Mitigation%20Measures%20-%20Volume%202%20-%20May%202009%20-%20WEBSITE%20APD.PDF http://www.environment.nsw.gov.au/climateChange/ipartreview.htm

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Mandatory assessment, audit or investment	Commonwealth	Energy Efficiency Opportunities Program	The Energy Efficiency Opportunities Act 2006 (Commonwealth) aims to improve the energy efficiency of the nation's largest energy-using businesses. Businesses using more than 0.5 petajoules of energy per year are required to conduct a detailed assessment of their energy use, and to identify opportunities to cost-effectively improve their energy efficiency. Implementation of opportunities is not mandatory. Corporations are also required to report to both the public and to government on the opportunities identified for projects with a financial payback of up to four years, and on their business decisions on implementation.	Commenced July 2006. Ongoing.	http://www.ret.gov.au/energy/efficiency/eeo/pages/default.aspx
	Commonwealth	Mandatory greenhouse gas emissions and energy use reporting	The National Greenhouse and Energy Reporting Act 2007 introduces a national mandatory reporting system for corporations that meet specified thresholds to report greenhouse gas emissions and energy consumption and production from July 2008. Introducing a single national reporting system ensures the collection of consistent and comparable data to inform government policy formulation and the Australian public. The system provides the basis for ongoing work with Commonwealth, State and Territory Government programs to better streamline reporting obligations and reduce the reporting burden placed on Australian businesses. A total of $19.7 million was budgeted for the period 2008-09 to 2011-12.	Commenced July 2008. Ongoing.	http://www.climatechange.gov.au/en/government/initiatives/national-greenhouse-energy-reporting.aspx
Synthetic greenhouse gas regulation	Commonwealth	Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 and Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995	The Act controls the import, export and manufacture of HFCs and PFCs, as well as ozone depleting substances. The Regulations provide end use controls to minimise preventable emissions of ozone depleting substances and HFCs in the refrigeration and air conditioning and fire protection industries by restricting access to these chemicals and setting minimum standards for its handling and minimum skills for people undertaking this work.	Synthetic greenhouse gases were included in the Act in 2003.	http://www.environment.gov.au/atmosphere/ozone/index.html
	Commonwealth	Development of Carbon Capture and Storage Offshore Regulatory Framework	Finalisation of regulations to support greenhouse gas injection and storage activities in Commonwealth Waters under the Offshore Petroleum and Greenhouse Gas Storage Act 2006.	Final set of Regulations (Greenhouse Gas Specific) are expected to be completed in March 2011.	http://www.ret.gov.au/resources/Documents/ccs/Regulation_Impact_Statement.pdf http://www.finance.gov.au/publications/strategic-reviews/docs/Climate-Report.pdf
Other regulation	State	CarbonTender (Victoria)	CarbonTender pays landholders to permanently revegetate a portion of their land with native plants to absorb harmful CO_2 and help make local ecosystems more able to adapt to climate change.	Ongoing.	http://www.dse.vic.gov.au/CA256F310024B628/0/9B102E4F443C933ACA2572E300111453/$File/CarbonTender_Brochure.pdf
	State	Vegetation Management Act 1999 (Queensland)	To regulate vegetation clearing in a way that conserves vegetation, prevents biodiversity loss and reduces greenhouse gas emissions.	Ongoing.	http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/V/VegetManA99.pdf
	State	Carbon Rights Act 2003 (WA)	A carbon right is a right to the benefits and risks arising from carbon sequestration and release on a specified parcel of land. Carbon rights may have a financial value where a market exists for greenhouse gas emission offsets. The Act establishes a statutory basis for the ownership and protection of carbon rights, in order to facilitate trading. It enables a carbon right to be registered on the land title as a separate interest in that land. The Act provides that a carbon right may be registered with the consent of all parties having an interest in the relevant land.	Commenced June 2003. Ongoing.	http://www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_113_homepage.html http://www.agric.wa.gov.au/objtwr/imported_assets/content/sust/carbon_rights.pdf
	State	Tree Plantation Agreements Act 2003 (WA)	The Tree Plantation Agreements Act 2003 (TPA) provides for the making and registration of tree plantation agreements. Under the TPA Act, ownership of trees can be separated from the ownership of land. In this way, investment in tree plantations is encouraged by making an investment in trees more certain.	Commenced June 2003. Ongoing.	http://www.landgate.wa.gov.au/corporate.nsf/web/Carbon+Rights,+Carbon+Covenants+and+Tree+Plantations http://www.austlii.edu.au/au/legis/wa/consol_act/tpaa2003274/

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	State	Actions to improve land management (WA)	The policy provides a foundation for endorsing and encouraging improved land management (particularly relating to fire management) to reduce emissions from savanna fires.	Initial project (WALFA) commenced in 1997. Analogous projects are now being developed.	
	Commonwealth	Carbon Farming Initiative	A carbon offsets scheme is being established by the Australian Government to provide new economic opportunities for farmers, forest growers and landholders and help the environment by reducing greenhouse gas emissions.	Election commitment but yet to be implemented.	http://www.climatechange.gov.au/government/submissions/carbon-farming-initiative.aspx
	State	EcoFund (Queensland)	An offsets exchange facility to assist developers in finding offsets for vegetation clearing.	Ongoing.	http://www.ecofund.net.au/for-landholders/how-we-work-with-landholders.html
Direct government expenditure					
Government procurement - general	State	QFleet ClimateSmart Action Plan 2007-2010 (procurement policy) (Queensland)	Minimum CO_2 emissions standards for government fleet vehicles, based on the Green Vehicle Guide (GVG) Greenhouse Ratings (5.5 for Passenger vehicles and 3.5 for all Light Commercial vehicles), unless approved by the agency CEO.	Ongoing.	http://www.qfleet.qld.gov.au/community/GI/Pages/Climatesmart.aspx
	State	Low Emission Bus Trial (Queensland)	Undertake a trial (at a cost of $1.4 million) of low-emission diesel-electric buses in the public transport fleet. This initiative will test the viability of hybrid bus technology under various Queensland conditions.	Commenced in 2010.	http://www.climatechange.qld.gov.au/pdf/factsheets/6transport-n7.pdf
	State	Renewable Energy program for Government Buildings (Queensland)	A centralised purchase system to meet the Government's ClimateSmart 2050 commitment that at least five per cent of electricity used in government buildings will be from renewable sources.	Ongoing.	
	State	Cleaner NSW Government Fleet Program	Efficiency targets for Government fleets. Cars with V8 engines are no longer available for purchase through Government contract. This program encourages the use of smaller, cleaner and less polluting vehicles. All general government agencies are required to create a fleet improvement plan to outline how the agency will meet the targets for the environmental performance of their fleet.	Commenced 2005-06. Ongoing.	http://www.ipart.nsw.gov.au/files/Final%20Report%20-%20Review%20of%20NSW%20Climate%20Change%20Mitigation%20Measures%20-%20Volume%202%20-%20May%202009%20-%20WEBSITE%20APD.PDF
	State	State Government Fleet Emission Target (SA)	The establishment of a new target to reduce emissions in the State Government fleet by 10 per cent by 2014-15 over the 2009-10 level, based on average grams per kilometre.	Runs from 2010-11 to 2014-15.	
	State	Energy efficient street light replacement (ACT)	Replacement of public street lights with more efficient lamps. $4.1 million was spent on this program from 2007-08 to 2008-09.	Runs from 2007-08 to 2009-10.	http://www.environment.act.gov.au/__data/assets/pdf_file/0005/201110/Kinesis_review_Action_Plan_1.pdf
	State	One Million Trees Initiative (ACT)	Aims to plant one million new trees over ten years as part of the ACT Climate Change Strategy. $16.21 million was identified for the project for the period 2007-08 to 2011-12. This funding will cover the planting and maintenance of 793 500 trees.	Runs from 2007-08 to 2016-17.	http://www.environment.act.gov.au/__data/assets/pdf_file/0005/201110/Kinesis_review_Action_Plan_1.pdf
	State	CNG Bus Fleet Replacement (ACT)	Progressive change-over of the ACTION bus fleet to compressed natural gas.	Ongoing.	
	State	Procurement requirements for Government purchases and projects (Tasmania)	The impacts of climate change are to be included in the evaluation criteria for all major purchases of goods and services and are to be taken into consideration in the selection of goods and services for all minor purchases of relevant goods and services. These impacts must also be taken into account in the planning, design, specification, construction, operation and ongoing maintenance of all relevant major building and construction of roads and bridges. The evaluation criteria for the selection of consultants and contractors must also include commitment to and capacity to deliver effective climate change outcomes.	Ongoing.	http://www.purchasing.tas.gov.au/buyingforgovernment/getpage.jsp?uid=2860591BA721F10FCA25747700820081

Policy type	Jurisdiction	Name	Description	Status and duration	References
	State	Isolated Communities Roof Top Solar (Queensland)	Installation (at a cost of $1 million) of small scale, roof-top, grid connected photovoltaic systems on Thursday Island, Horn Island, Boulia & Bamage.		http://www.dme.qld.gov.au/media_centre.cfm?item=956.00
	State	Green Fleet initiative (NT)	Aims to reduce greenhouse gases produced by the Government's light commercial and passenger vehicle fleet. A 20 per cent reduction target over five years has been set.	Commenced July 2009.	http://www.nt.gov.au/ntt/financial/budget09-10/factsheets/protecting_the_environment.pdf
	State	NSW Government Sustainability Policy	In May 2008, targets and strategies were announced for NSW Government agencies to reduce greenhouse gas emissions from energy, waste and fleet management, and sustainable purchasing. These include a state-wide target for NSW Government agencies to reduce greenhouse gas emissions from building energy use to 2000 levels by 2019-20 (using interim targets), and compliance with the Cleaner NSW Government Fleet Policy.	Policy commenced in 2008 with some targets to 2020. Reporting requirements expire 2011-12 unless renewed, following the recommendations of the internal Government Red Tape review. Policy is currently being reviewed by DECCW.	http://www.ipart.nsw.gov.au/files/Final%20Report%20-%20Review%20of%20NSW%20Climate%20Change%20Mitigation%20Measures%20-%20Volume%202%20-%20May%202009%20-%20WEBSITE%20APD.PDF
Government procurement - carbon offsets	State	Greening the WA Government Vehicle Fleet	Two fold program (at a cost of $900 000 per annum) involving a targeted reduction in vehicle CO_2-e emissions. Vehicle acquisitions are assessed against an annually reducing benchmark target for CO_2-e emissions per kilometre travelled. The second part of the program involves offsetting the equivalent of the annual CO_2-e vehicle emissions through Australian Greenhouse Office approved programs.	Commenced in 2006. Ongoing.	http://www.dtf.wa.gov.au/cms/uploadedFiles/Government_Procurement/Buyers/State_Fleet/state_fleet_greenhouse_gas_emissions_report.pdf?n=1728
	State	Government air travel reduction and offset program (Tasmania)	From March 2008, a proportion of all Tasmanian Government air travel expenses will be invested towards a biodiverse carbon sequestration research project in Tasmania.	Commenced March 2008.	http://www3.dpac.tas.gov.au/divisions/policy/climate/
	State	QFleet ClimateSmart Action Plan 2007-2010 Part 2 (offset policy) (Queensland)	Offsetting 50 per cent of emissions from the Queensland Government vehicle fleet by 2010 and 100 per cent by 2020.	Ongoing.	
	State	Offset government domestic and international air travel and hire vehicles (Queensland)	A purchasing framework that ensures carbon offsets are purchased to negate the greenhouse gas emissions associated with air travel and vehicle hire by government departments.	Commenced December 2007.	http://www.qgm.qld.gov.au/00_downloads/Carbon_offsets.pdf
	State	Victorian Government Carbon Neutral Fleet Program	Carbon offsets purchased to offset the emissions of the government fleet and encourage the development of a market for carbon offsets in Victoria.	Commenced 2001.	http://www.resourcesmart.vic.gov.au/documents/vicgov_offsets.pdf
	State	Carbon Neutral NSW Government	In May 2008, the NSW Government announced that it will become 'carbon neutral' by 2020. The operations of the NSW Cabinet are to become carbon neutral from mid 2009.	Runs from 2007-08 to 2019-20.	http://www.ipart.nsw.gov.au/files/Final%20Report%20-%20Review%20of%20NSW%20Climate%20Change%20Mitigation%20Measures%20-%20Volume%202%20-%20May%202009%20-%20WEBSITE%20APD.PDF http://www.environment.nsw.gov.au/climateChange/ipartreview.htm
Government investment - infrastructure	State	Government Sustainable Energy Targets (Victoria)	Reduce energy use in government buildings by a further 5 per cent to 20 per cent of 1999-2000 levels by 2010 and increase use of Green Power to 25 per cent.		http://www.sustainability.vic.gov.au/www/html/2452-new-energy-measures-.asp

Policy type	Jurisdiction	Name	Description	Status and duration	References
	State	Expansion of Park and Ride (WA)	$49.5 million for the expansion of 'Park and Ride' bicycle facilities and feeder bus services.	Announced 2008 and expected to be completed in March 2012.	
	State	Government Energy Efficiency Program (NT)	A funding mechanism to support the NT Energy Smart Building Policy. The program enables increased prioritisation of energy efficiency projects for five NT Government agencies (which are responsible for 86.5 per cent of the total building energy use). Under the program, $6 million (over three years) has been allocated to make government buildings more energy efficient.	Runs from July 2008 to 30 June 2011.	http://www.nt.gov.au/dlp/sustainability/geep/documents/GovernmentEnergyEfficiencyProgramFactSheet.pdf
	State	Energy efficient government buildings (SA)	The Government's Energy Efficiency Action Plan outlines a suite of measures to improve the energy efficiency of State Government owned and leased buildings.	Ongoing.	http://www.sa.gov.au/upload/franchise/Water,%20energy%20and%20environment/energy/energy_efficiency/documents/Government_Energy_Efficiency_Action_Plan.pdf
	State	Energy efficiency improvements in government housing (ACT)	A $20 million initiative over 10 years which includes improvements such as wall insulation, draught sealers and more efficient heating.	Runs from 2007-08 to 2016-17.	http://www.environment.act.gov.au/__data/assets/pdf_file/0010/151597/CCNEWS3.pdf
	State	Strategic Energy Efficiency Policy for Government Buildings (Queensland)	Requirement for each department to develop and implement a Strategic Energy Management Plan for its building portfolio and achieve energy reduction targets of 5 per cent by 2010 and 20 per cent by 2015.		http://www.works.qld.gov.au/tdd/climate/energy_management.asp
	State	Electric Vehicle Recharging Infrastructure Pilot (SA)	Installation of Adelaide's first public 'smart' electric vehicle recharging station and first ceramic fuel cell at the Adelaide Central Market. The electricity produced by the 2kW ceramic fuel cell is used to supply power to the two 15-amp bollards, with any additional power required topped up by solar panels and/or 50 per cent GreenPower. This project will cost $90 000, inclusive of all services and signage.	Announced December 2010.	http://www.cfcl.com.au/Assets/Files/20101220_CFCL_Media_Release_ACC_WORLD_FIRST_FOR_ELECTRIC_CARS.pdf
	State	Energy Smart Buildings Program (Queensland)	A whole-of-government program to promote and facilitate energy efficiencies in government buildings.		http://www.climatechange.qld.gov.au/pdf/factsheets/8govlship-b1.pdf
	State	Mini wind turbine trial (SA)	A 12 month trial of four residential-scale mini wind turbine technologies, so as to test the performance of commercially available technologies in South Australian conditions. This program will cost $0.35 million.	Turbines scheduled for installation in March 2011. Their performance will be monitored over a 12-month period.	
	State	School Energy Efficiency Program (NSW)	Provides grants to retrofit energy efficient lighting in up to 150 government high schools in NSW over the period 2007-2012 and fund projects initiated by high schools that deliver energy and greenhouse gas savings over the period 2009-2012. The overall budget for the lighting stream is $20 million.	Runs from 2007-08 to 2011-12.	http://www.environment.nsw.gov.au/grants/ssep.htm http://www.ipart.nsw.gov.au/files/Final%20Report%20-%20Review%20of%20NSW%20Climate%20Change%20Mitigation%20Measures%20-%20Volume%202%20-%20May%202009%20-%20WEBSITE%20APD.PDF http://www.environment.nsw.gov.au/climateChange/ipartreview.htm
	State	Upgrade to energy efficient traffic signals (Tasmania)	$3.1 million to roll out energy-efficient traffic signals system using Extra Low Voltage/Light Emitting Diode (ELV/LED) technology. The new technology uses about 70 per cent less electricity (based on lights and system electricity use) and has a life span of 10 to 15 years, compared with only three years for current signal globes.	Ongoing and expected to be completed by 2020.	http://www.dpac.tas.gov.au/divisions/climatechange/framework/26
	State	Electronic Speed Limit Signs (Tasmania)	Solar powered Electronic Speed Limit Signs are being installed in school zones (mains powered signs have been installed only where solar was impractical).	Ongoing.	

Policy type	Jurisdiction	Name	Description	Status and duration	References
	State	Minimum sustainability standards for government buildings (Tasmania)	Tasmanian Government agencies are now required to meet minimum sustainability standards for government office buildings and develop a green lease.		
	State	Faster, Better, Safer Walking and Cycling (Queensland)	Accelerate the planning and development of key walking and cycling infrastructure in South East Queensland. Gaps in the network close to key destinations such as the Brisbane CBD, the University of Queensland and Fortitude Valley will be prioritised so that interconnected walking and bike paths can assist Queenslanders to reduce their carbon footprint.	Runs from 2009 to 2012.	http://www.climatechange.qld.gov.au/pdf/factsheets/6transport-n5.pdf
	State	Solar and Energy Efficiency Program for Queensland's State Schools (Queensland)	$60 million package over three years for solar panels, energy efficient light bulbs, and circuit timers to turn off non-essential power at night.	Runs from 2008-09 to 2011-12.	http://education.qld.gov.au/facilities/solar/energy.html http://www.thepremier.qld.gov.au/library/pdf/initiatives/climate_change/ClimateSmart_2050.pdf
	State	Improved Traffic Flow for Reduced Emissions (Queensland)	Improve traffic flow on the major road network by installing new technologies to coordinate traffic signals and on-ramps, vary speed limits, control lanes and monitor traffic. The systems will also collect traffic data and assist with future network planning.	Commenced 2009.	http://www.climatechange.qld.gov.au/pdf/factsheets/6transport-n1.pdf
	State	Carbon Reduction Strategy for Government Office Buildings (Queensland)	By 2020, government-owned office buildings required to achieve 'carbon neutral' status (zero net greenhouse gas emissions). This will be achieved through: energy savings (for example, mandating minimum air-conditioning temperatures); sourcing renewable energy; and purchasing carbon offsets. Also, all new and major refurbished office buildings are to have at least a 4.5 star energy rating.	Commenced July 2008.	http://www.works.qld.gov.au/downloads/tdd/climate-smart-buildings_crs.pdf
	Commonwealth	Energy Efficiency in Government Operations	Requires Australian Government office buildings to meet energy intensity targets by June 2011. The policy also includes minimum standards that must be met in terms of energy ratings for leased office buildings, lighting, office equipment and appliances and energy reporting.	Original policy commenced 1997. A new policy was introduced in 2006.	http://www.climatechange.gov.au/publications/energy-efficiency/eeo-in-government-operations-policy.aspx
	State	Sustainable Transport Plan, including mode shift targets (ACT)	The ACT Sustainable Transport Plan (2004) set mode shift targets to increase trips to work by walking, cycling and public transport to 20 per cent by 2011, and 30 per cent by 2026. A suite of policies and projects under the banner of 'Transport for Canberra', including investments in public transport infrastructure, services, passenger information and promotion, will support the achievement of these targets. Emissions reductions occur through a reduction in kilometres travelled by private motor vehicle. The 2010-11 Budget included $97 million for investment in sustainable transport.	Released in 2004 and part of the Territory's legislated planning strategy. Targets are to be reviewed in 2011-12 in light of transport share of legislated emissions reduction targets.	http://www.transport.act.gov.au
	State	Green Schools (ACT)	$20 million will be invested over 10 years to assist government and non-government schools to become carbon neutral by 2017, through the development of emissions reduction and energy efficiency initiatives. Grants have been provided to non-government schools for projects to assist them in becoming carbon neutral. The installation of solar power generation systems at public schools has commenced. A range of energy efficiency measures have been included in the Building the Education Revolution projects and all new schools aim to achieve a five Green Star rating from the Green Building Council of Australia.	Runs from 2007-08 to 2016-17.	http://www.det.act.gov.au/__data/assets/pdf_file/0007/26953/GreenSchools.pdf
Support for research and development					
R&D - general and demonstration	State	Biofuels from microalgae (SA)	$1.2 million support for a joint project by the South Australian Research and Developement Institute, and Flinders University to initiate development of new capabilities in the area of biofuels from microalgae. Funding is provided through the Premier's Science and Research Fund.	Commenced 2008-09.	http://www.sardi.sa.gov.au/information_and_news/media_release_archive/media_releases_2008/microalgae_for_biodiesel_research_fuelled_by_fresh_initiative

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	State	Victorian Hybrid Bus Trial	Demonstration/evaluation of two hybrid-electric bus technologies within Victoria's public transport system at a cost of $600 000.	Runs from 2008 to 2011.	http://www.transport.vic.gov.au/doi/internet/ict.nsf/headingpagesdisplay/sustainable+transport+projects+and+programs#hybridbus http://www.transport.vic.gov.au/web23/Home.nsf/AllDocs/946FAA39288478D6CA2577F5001EA54B?OpenDocument
	State	Renewable Energy Fund (SA)	The establishment of a Renewable Energy Fund ($20 million) to support ongoing investment, research and development in renewable energy in the State.	Established in 2009 for a two year initial term.	http://www.renewablessa.sa.gov.au/
	Commonwealth	Clean Energy Initiative - Education and Investment Fund Component	Supports R&D and demonstration of low-emission energy technologies through the Carbon Capture and Storage Flagships and Solar Flagships programs.	Runs from 2010-11 to 2013-14.	
	Commonwealth	CSIRO climate change related research (excluding Energy Flagships)	Funding of $82.6 million over the period 2007-08 to 2011-12 for CSIRO's other climate change related activities.	Ongoing.	
	Commonwealth	DAFF Climate Change Research Program	Funds research projects and on-farm demonstrations to help prepare Australia's primary industries for climate change and build the resilience of our agricultural sector in the future. Research focuses on reducing greenhouse pollution, better soil management and climate change adaptation.	Commenced June 2008.	
	State	Greenhouse in Agriculture - Responding to Climate Change (Victoria)	Research and development work to reduce greenhouse gases from agricultural processes.	Commenced 2008.	
	Commonwealth	National Low Emissions Coal Initiative	An eight year program to support low emissions coal and advanced fossil fuel technology development through initiatives, including: $50 million for a national carbon mapping and infrastructure plan; $75 million for a National Clean Coal Research program (including $25 million to support low emission coal research by the CSIRO); $50 million for a pilot coal gasification plant in Queensland; $50 million to demonstrate carbon capture and storage in NSW; $50 million for a carbon capture and storage plant in the Latrobe Valley (Vic); $50 million for the LETDF Calide oxyfuel project; $15 million to fund Australia's Involvement in the FutureGen Alliance; and $20 million for the Australia-China Clean Coal Co-ordination Group.	Runs from 2007-08 to 2014-15.	http://www.ret.gov.au/resources/resources_programs/nleci/Pages/NationalLowEmissionsCoalInitiative.aspx
	State	Support for carbon capture and storage research (SA)	This scheme underpins R&D for carbon capture and storage. The focus in South Australia will be ascertaining optimum subsurface sites for greenhouse gas storage that will be required if syngas and/or synfuel enterprises are commissioned in the State. This funding also secured the co-location of 9 to 12 CO_2CRC cohorts with the Australian School of Petroleum and the South Australian Centre for Geothermal Energy Research, providing economies of scale in applied research into subsurface technologies and methodologies for petroleum, geothermal and gas storage.	Commenced 2010-11. Ongoing.	
	Commonwealth	Emerging Renewables	$40 million program to provide support for technologies that offer significant potential as future sources of baseload power, like wave and geothermal.	Election commitment. Funding commences in 2011.	http://www.ret.gov.au/energy/Documents/cei/CEI%20Factsheet.pdf
	Commonwealth	Australian Biofuels Research Institute	$20 million from ACRE funding to establish the Australian Biofuels Research Institute at James Cook University. ACRE is responsible for coordinating the creation of the institute. ACRE expects that the institute will consolidate and coordinate existing research and development in Australia, and facilitate the demonstration and commercialisation of biofuels technologies.	Election commitment. Funding commences in 2011.	http://www.ret.gov.au/energy/Documents/cei/CEI%20Factsheet.pdf

Policy type	Jurisdiction	Name	Description	Status and duration	References
	Commonwealth	Australian Solar Institute	Initiative to support solar thermal and solar photovoltaic R&D. This commitment will foster greater collaboration between solar researchers in universities, research institutions and industry and help forge strong links with peak overseas solar research organisations. An additional $50 million was announced in 2010 to support the US-Australia Solar Energy Collaboration. The overall budget for this program is $150 million.	Runs from 2008-09 to 2013-14.	http://www.ato.gov.au/budget/2009-10/content/bp2/html/bp2_expense-22.htm
	State	Centre for Energy and Greenhouse Technology (Victoria)	A $29 million fund provided by the Victorian Government focusing on the development of new sustainable energy, energy efficiency and greenhouse gas reduction technologies. The Centre for Energy and Greenhouse Technology fund is managed by CleanTech Ventures P/L.	Commenced 2003. Now self sufficient and ongoing.	http://new.dpi.vic.gov.au/energy/projects-research-development/etis/cegt
	Commonwealth	Education Investment Fund - Sustainability Round	Three research infrastructure projects were awarded a total of $102.4 million through the Education Investment Fund Sustainability Round to support research into sustainable energy use, sustainable building technologies and clean energy generation systems for the Square Kilometre Array.	Funding for the projects commenced in January 2011 with one project funded until 2011-12, one project funded until 2012-13 and one until 2013-14.	
	State	Brown Coal Innovation Australia (BCIA) (Victoria)	Established in 2009 with $16 million funding from the Victorian Government to continue funding new low emissions coal R&D in Victoria. BCIA is an independent company that has a mandate to co-invest with industry and research entities in skills development and R&D projects in new high quality brown coal technologies and in adaptation of existing low-emissions technologies to Victorian brown coal. BCIA coordinates all brown coal R&D in Australia in conjunction with the Commonwealth's National Low Emissions Coal R&D organisation.	Commenced 2010, initially for four years.	http://new.dpi.vic.gov.au/energy/projects-research-development/etis/brown-coal http://www.invest.vic.gov.au/250809Victoriaestablishes16mcleancoalresearchbody
	State	Clean Coal Fund (New South Wales)	Provides $100 million to fund research, demonstration and commercialisation of clean coal technologies and to increase public awareness of the importance of reducing greenhouse gas emissions through clean coal technologies. This program aims to reduce greenhouse emissions, encourage R&D, promote industry development and demonstrate technologies for adoption by the private sector. It is financed through a levy on electricity distributors under the Energy and Utilities Administration Act 1987 beginning in 2009-10.	Runs from 2009-10 to 2012-13.	http://www.dpi.nsw.gov.au/minerals/resources/low-emissions-coal/nsw-clean-coal-council-and-clean-coal-fund
	State	Clean Coal Fund (Queensland)	$300 million allocated from the Queensland Future Growth Fund to develop carbon capture and storage technologies. This project involves collaboration with the State's coal industry which contributed $600 million.	Commenced. Ongoing.	http://www.dme.qld.gov.au/Energy/energy_policy.cfm
	State	Centre of Excellence for Research into Energy for Sustainable Transport (WA)	Established to coordinate research and development to assist WA in the transition to a sustainable transport system. Projects include safer and cheaper batteries for electric vehicles and identifying optimum sites for industrial scale microalgae biofuel production. $1.3 million has been budgeted for 2009 to 2011.	Commenced April 2008. Agreement extended and now concludes in 2012.	
	State	Western Australian Geothermal Centre of Excellence	Established to develop a research and industry base founded on the utilisation of Hot Sedimentary Aquifers for the generation of low grade/direct geothermal heat energy. $1.6 million has been budgeted for 2010 to 2012.	Commenced 2009. Due for completion in 2013.	
	State	NSW Storage Capacity Project	A State-Wide assessment of CO_2 Storage Capacity projects with two aims: 1. in the immediate term, identify storage for a carbon capture and storage demonstration project by 2012; and 2. inform the medium to longer term outlook by undertaking a State-wide assessment of potential storage opportunities in NSW to prepare pre-competitive data for acreage release.	Runs from 2009-10 to 2012-13.	http://www.dpi.nsw.gov.au/minerals/resources/low-emissions-coal/nsw-storage-capacity-project
	State	Location of geosequestration sites (NSW)	Funding to locate geosequestration sites, including a possible site for a demonstration scale carbon capture and storage project. This program has an objective of industry development and encouraging R&D.		http://www.dpi.nsw.gov.au/minerals/geological/publications/reports/reservoir-prediction-study

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	State	NSW Carbon Capture and Storage Demonstration Project	Project to demonstrate post-combustion capture, treatment and permanent geological storage of carbon dioxide (up to 100 000 tonnes of CO_2 per annum in a saline aquifer) from a black coal power station. The NSW Government, Commonwealth Government and Australian Coal Association Low Emission Technology (ACALET) have signed a funding agreement ($28.3 million) with Delta Electricity for a 'Development and Approvals' Stage (Stage 1) for the Delta Demonstration Project.	Commenced 2009-10.	http://www.dpi.nsw.gov.au/minerals/resources/low-emissions-coal/nsw-carbon-capture-and-storage-demonstration-project
	State	Victorian Geological Carbon Storage	Research and modelling of the Gippsland region's geology to better understand carbon storage potential.	Runs from 2008-09 to 2011-12.	http://new.dpi.vic.gov.au/earth-resources/about/initiatives/vicgcs
	State	Queensland Sustainable Energy Innovation Fund	For energy and water projects. Currently, grants of up to 80 per cent of project costs (up to $200 000) are available through competitive merit based assessment. $8.9 million has been allocated in funding since1999.	Commenced 1999. Ongoing.	http://www.derm.qld.gov.au/qseif/
	State	Carbon Geostorage Initiative (Queensland)	Funding for the assessment, evaluation and categorisation of geological sites in Queensland with the potential for long-term safe and secure storage of carbon dioxide emissions. The overall budget for this scheme is $10.0 million.		http://www.dme.qld.gov.au/Energy/energy_policy.cfm http://www.energyfutures.qld.gov.au/carbon_geostorage_initiative.cfm
	State	Clean Technology (Victoria)	Provided support ($4.5 million) for business projects that demonstrated innovative solutions to reduce greenhouse gas emissions.	Commenced 2004. Concluded 2011.	
	State	South Australian Geothermal Energy Research Centre	Funding ($1.6 million in 2010-11) provided to support the establishment of the research centre at the University of Adelaide.	All grant payments under the funding agreement have been completed in 2010-11.	
R&D - deployment and diffusion	Commonwealth	Carbon Capture and Storage Flagships Program	The CCS Flagships program will demonstrate large scale integrated CCS in Australia to support widespread national and international deployment of CCS technology from 2020. The CCS Flagships projects will be industrial scale demonstrations that will contribute to meeting 1000 MW of low emissions fossil fuel power generation in Australia, or which demonstrate CCS in relation to industrial processes. The Australian Government anticipates that the economic and technical research findings generated through the design, construction and early operation of these plants will be widely disseminated to progress deployment of CCS technology both domestically and internationally.	Runs from 2009-10 to 2017.	http://www.ret.gov.au/resources/resources_programs/cei/ccsfp/Pages/default.aspx
	State	Victorian Electric Vehicle Trial	Market-development initiative for electric vehicle technologies.	Runs from 2010 to 2014.	http://www.transport.vic.gov.au/web23/Home.nsf/AllDocs/246D50F44EB2272DCA2576A50015AE1E?OpenDocument
	Commonwealth	Solar Flagships Program	Supports the construction of up to four large scale, grid-connected, solar power plants in Australia using solar thermal and photovoltaic technologies. The Government's aim is to establish up to 1000 MW of solar power generation capacity. Project selection is to occur over two selection rounds. The first selection round (Round 1) is underway and is to select one solar thermal and one photovoltaic project in the first half of 2011, with a target of 400 MW of combined generation capacity across both projects. The second selection round (Round 2) is planned to be held in 2013-14, following a review of the outcome of Round 1. The total budget for this program is $1.48 billion.	Runs from 2008-09 to 2014-15.	http://www.ret.gov.au/energy/energy%20programs/cei/sfp/round-one/Pages/round-1.aspx
	State	Queensland Renewable Energy Fund	$50 million funding to support the development and deployment of renewable energy generation technologies in Queensland.	Commenced.	http://www.cleanenergy.qld.gov.au/queensland_renewable.cfm

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	Commonwealth	Global Carbon Capture and Storage Institute	$305 million funding for a Global Carbon Capture and Storage (CCS) Institute which aims to accelerate the development and deployment of a global portfolio of industrial-scale CCS demonstration projects. It will facilitate demonstration projects, establish information sharing frameworks, remove regulatory and legal impediments to CCS projects globally and, where necessary, identify and support research related to commercial deployment of CCS.	Runs from 2008-09 to 2016-17.	http://new.globalccsinstitute.com/institute/
	Commonwealth	Australian Centre for Renewable Energy (ACRE)	Established as a component of the Clean Energy Initiative to promote the development, commercialisation and deployment of renewable energy and enabling technologies, and drive down their costs. ACRE consolidates over $690 million in funding for renewable energy and enabling technology development. This includes a number of existing programs (REDP, ACRE Solar Projects, GDP, Second Generation Biofuels Research and Development Program) as well as new initiatives (REVCF and Emerging Renewables). ACRE has a statutory independent advisory Board that is developing a strategy for ACRE to integrate its activities and guide new funding support decisions.	2009 budget commitment (CEI). ACRE Act passed March 2010.	http://www.ret.gov.au/resources/resources_programs/cei/acre/Pages/default.aspx
	Commonwealth	Renewable Energy Venture Capital Fund	The Fund will provide venture capital and active investment management to encourage the development of Australian companies that are commercialising renewable energy and technologies. The initiative aims to address a major challenge facing renewable energy companies – access to capital. The REVC Fund will make critical early-stage equity investments that leverage private funds to help commercialise emerging renewable technologies, for instance in geothermal, solar, wave and bio-energy technologies.	Commences 2011-12.	http://www.ret.gov.au/energy/energy%20programs/cei/acre/vcf/Pages/default.aspx
	Commonwealth	National Energy Efficiency Initiative - Smart Grid, Smart City	Partnership with industry to build a commercial scale energy management project. This initiative will gather robust information about the costs and benefits of smart grids to inform future decisions by government, electricity providers, technology suppliers and consumers across Australia. The overall budget for this scheme is $100 million.	Commenced 2009-10. Due to end 2013.	http://www.ret.gov.au/energy/energy%20programs/smartgrid/pages/default.aspx
Other					
Information provision or benchmarking	Commonwealth	Your Development	A joint initiative of the Australian Government and the CSIRO and urban planners around Australia. Your Development is a dynamic website providing information on sustainable urban development, including fact sheets and case studies.	Commenced 2008.	http://yourdevelopment.org/
	State	Public Transport Planning Tool (Queensland)	$1.3 million to develop a planning tool that measures how easy it is for people to access important services such as hospitals, schools, shops and workplaces by walking, cycling and public transport. The software allows planners to investigate possible improvements to accessibility through provision of improved walkability, high frequency public transport and appropriate mixes of land-use around transport hubs.	Runs until 2012.	http://www.climatechange.qld.gov.au/pdf/factsheets/6transport-n6.pdf
	Commonwealth	Your Home	A joint initiative of the Australian Government and the design and construction industries. Your Home is a suite of consumer and technical guide materials and tools developed to encourage the design, construction or renovation of homes to make them comfortable, healthy and more environmentally sustainable.	Commenced 2008.	http://www.yourhome.gov.au/about/index.html
	State	Expansion of Sustainability Advantage Program (NSW)	Assist 800 medium to large businesses to identify and implement measures to save energy, water, waste and other resources. This includes subsidised energy audits and technology diffusion (Energy Saver) as well as workshops, training and technical assistance. $20 million has been budgeted from June 2009 to June 2013 for the expansion phase.	Original Sustainability Advantage program established November 2006.	http://www.environment.nsw.gov.au/sustainbus/sustainabilityadvantage.htm
	State	Sustainable Community Rating (Victoria)	A tool for developers to use to raise the standard of planning of residential estates. The goal is to reduce building/operating environmental impacts.		http://www.sustainablecommunityrating.com/cs/Satellite?c=VPage&cid=1191565167442&pagename=VicUrban%2FLayout&site=Sustainability

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	State	Innovation in agriculture (Victoria)	Enables Victorian farmers to participate in the Commonwealth's proposed carbon offset market from 2011 onwards without putting Victoria's existing food and fibre production at risk.	Commenced 2010.	
	State	Carbon Innovators Network (Victoria)	A website, forum and information service for members to stimulate debate and innovation in carbon management. The network currently has over 1100 members, representing business and industry, government, and not-for-profit sectors.		http://www.epa.vic.gov.au/climate-change/carbon-innovators/default.asp
	State	Information for Renewable Energy Investors (SA)	Establishing RenewablesSA as a central point of information dissemination on the State's wind, solar and wave resources and to provide guidance for investors on the State's policies and processes.	Ongoing.	
	State	Carbon Management Information and Tools (Victoria)	Provides information to businesses (among others) to develop greenhouse gas emission strategies to reduce emissions (through energy efficiency and new technology).		
	State	Energy Efficiency Community Awareness Program (NSW)	This community awareness program will provide practical advice on how to save energy at home and work. It includes a communication campaign to encourage energy efficiency, a mix of education programs and training initiatives and research into consumer behaviour related to energy efficiency.	Runs from 2008-09 to 2011-12.	http://www.ipart.nsw.gov.au/files/Final%20Report%20-%20Review%20of%20NSW%20Climate%20Change%20Mitigation%20Measures%20-%20Volume%202%20-%20May%202009%20-%20WEBSITE%20APD.PDF
	Commonwealth	Green Vehicle Guide	An internet based searchable database providing information and environmental performance ratings (air pollution and greenhouse gas emissions data) for all new road vehicles sold in Australia, since 2004, weighing 3.5 tonnes gross vehicle mass or less. $1.5 million has been budgeted for this program for the period 2004-05 to 2007-08.	Established August 2004. Ongoing.	http://www.greenvehicleguide.gov.au/GVGPublicUI/Information.aspx?type=FrequentlyAskedQuestions http://www.budget.gov.au/2004-05/ministerial/html/environment-07.htm
	State	Switch your thinking (ACT)	$19.1 million over four years to extend and expand existing sustainability programs relating to water, energy and waste, and streamlines these into a one-stop-shop delivery vehicle. Aimed at encouraging the ACT community to reduce water usage, energy consumption and waste production.	Commenced 2009-10.	www.actsmart.act.gov.au
	Commonwealth	Energy Efficiency Exchange Website	Website to provide best practice energy efficiency information for industry (delivered through the Commonwealth-State jointly funded National Framework for Energy Efficiency).		http://www.ret.gov.au/energy/efficiency/energyeffx/Pages/default.aspx
	State	Fleetwise Partnership (NSW)	Provides free introductory seminars, information, modelling and advice on low emissions fleets to fleet operators to improve the sustainability of vehicle fleets. The program also aims to reduce greenhouse gases and to reduce fuel costs by increasing the number of fuel efficient vehicles entering the used vehicle market. The program contains two modules; one for light vehicles (up to 3.5 tonnes gross vehicle mass) and one for heavy vehicles. NSW is undertaking a project to determine environmental performance benchmarks for heavy vehicles across a range of operating duty cycles.	The light vehicle module of FleetWise is operational in NSW and is administered by the DECCW. The program is ongoing. Several other jurisdictions intend to rollout the program and NSW is liaising to assist potential national rollout. The NABERS precedent for rolling out NSW programs nationally is being used as a guide. Heavy vehicle benchmarking will contribute to a FleetWise heavy vehicle project to be further developed beyond 2010-11.	http://www.cleartheair.nsw.gov.au/fleetwise/ http://www.ipart.nsw.gov.au/files/Final%20Report%20-%20Review%20of%20NSW%20Climate%20Change%20Mitigation%20Measures%20-%20Volume%202%20-%20May%202009%20-%20WEBSITE%20APD.PDF
	State	TravelSmart Workplaces and Events (Queensland)	Web-based tools, direct assistance and demonstration projects will be undertaken to promote and assist major workplaces, event managers and popular locations to develop, implement and advertise travel plans to reduce private car use.	Runs from 2008 to 2012.	http://www.travelsmart.qld.gov.au/TravelSmart-projects/TravelSmart-Workplaces-and-Events.aspx

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	State	TravelSmart Schools (Queensland)	School Travel Plans will be developed to establish a school community's current transport behaviour, and to identify ways for individuals to adopt active, shared and public transport alternatives. The overall budget for the program is $4.97 million.	Runs from 2008 to 2012.	http://www.travelsmart.qld.gov.au/TravelSmart-projects/TravelSmart-schools.aspx
	State	ClimateSmart Living education campaign (Queensland)	Funding to promote actions to reduce greenhouse gas emissions at home and work. The overall budget for the campaign is $2.5 million.		http://www.thepremier.qld.gov.au/library/pdf/initiatives/climate_change/ClimateSmart_2050.pdf
	Intergovernmental	Australian Sustainable Schools Initiative (AuSSI)	A partnership of the Australian Government and the states and territories that seeks to support schools and their communities to become sustainable. AuSSI engages participants in a whole-of-school approach, to explore through real-life learning experiences, improvements in a school's management of resources and facilities including energy, waste, water, biodiversity, landscape design, products and materials. $4.5 million has been invested by the Australian Government between 2002-2011. Further funds have been invested by other jurisdictions.	Commenced with a pilot in NSW and VIC in 2003-2004. Endorsed by EPHC in 2008. Status of AuSSI differs across jurisdictions, but currently covers 30 per cent of all Australian schools.	http://www.environment.gov.au/education/aussi/publications/pubs/aussi-factsheet.pdf
	State	Household Audit and Education Program - Living Smart (WA)	This program ($500 000 per annum plus partnership funding) provides practical information on how greenhouse gas emissions can be reduced in the household by focusing on transport, energy, water and waste behaviours. 10 000 homes have been offered the service in 2010-11 as part of the Perth Solar City program.	Living Smart continues to be delivered as part of the Perth Solar City program. A Living Smart Workplace program has been developed and tested and may be delivered further in 2011-12.	http://portal.environment.wa.gov.au/pls/portal/docs/PAGE/DOE_ADMIN/GREENHOUSE_REPOSITORY/TAB6327544/2007006CLIMATECHANGE.PDF
	State	TravelSmart (WA)	TravelSmart is a community based program that involved groups and organisations in activities to encourage more walking, cycling and teleaccess, the use of public transport, and less 'driver-only' journeys.	TravelSmart Household 2000-2007 reached 418 500 residents. It is currently delivered as part of the Living Smart program.	http://www.transport.wa.gov.au/tsmart_tenyearplan.pdf http://www.dec.wa.gov.au/component/option,com_docman/task,doc_download/gid,4341/Itemid,/
	State	Climate Smart Business Service (Queensland)	Support ($15 million over the five years 2010 to 2015) for Queensland's small and medium enterprises to reduce greenhouse gas emissions and prepare for higher energy and other operating costs that are likely to be driven by the transition to a low carbon economy.	Committed.	http://www2.business.qld.gov.au/tools-resources/566.htm
	Commonwealth	Living Greener (previously One Stop Green Shop)	$3 million over three years to assist households and schools to easily access energy and water efficiency advice and assistance. This scheme links families and schools to all Australian Government, State and Territory Government household efficiency programs through a single, user friendly government web portal. Current funding ends June 2011. Ongoing funding is required to expand the site to include information for small and medium sized enterprises and local government programs along with upgrading functionality of the site.	Commenced 2008-09. Funded to 2010-11.	http://www.climatechange.gov.au/about/budget/previous-budget/~/media/publications/budget/0809/ccbo-0809.ashx
	State	Greenhouse Regional Partnerships Program (Victoria)	The regional partnerships provide a means for local organisations to work together on reducing greenhouse emissions while at the same time building stronger links with relevant local and State Government programs.		http://www.ourwater.vic.gov.au/__data/assets/pdf_file/0016/73231/MAVLocalGovernmentCaseStudies2007.pdf
	State	ResourceSmart Business Program (Victoria)	Provides information and financial support to SMEs for projects that reduce greenhouse gas emissions.		http://www.resourcesmart.vic.gov.au/for_businesses/energy_2101.html
	State	Towards Zero Waste initiatives (Victoria)	A range of initiatives to reduce waste and associated emissions.		http://www.business.vic.gov.au/BUSVIC/STANDARD/PC_62714.html
Labelling scheme	Commonwealth	Windows Energy Rating Scheme	A system of energy performance labelling for window products, developed by the window and glazing industry and supported by the Australian Government.	Commenced 2001. Ongoing.	http://www.climatechange.gov.au/what-you-need-to-know/buildings/initiatives.aspx#wers

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	Commonwealth	Expansion and revision of Vehicle Fuel Consumption Labelling Standard	Mandatory labelling requirement for new vehicles commenced in January 2001. Since January 2004, there have been expanded requirements for vehicle fuel consumption labelling, including the requirement to label carbon dioxide emissions as well as fuel consumption to include all new vehicles up to 3.5 tonnes gross vehicle mass, and to use fuel consumption and carbon dioxide emissions figures from a UN test procedure. Since April 2009, the label has been revised to improve information available to consumers by providing a breakdown of test results reflecting both urban and non-urban driving conditions. In 2010, the labelling standard was expanded to include an energy consumption label suitable for electric vehicles and plug-in hybrid vehicles.	Commenced 2001. Ongoing.	http://www.infrastructure.gov.au/roads/environment/index.aspx
	Intergovernmental	Mandatory energy efficiency labelling for appliances	Prescribes labelling of comparative energy consumption for specific types of major energy-using products in the residential, commercial and industrial sector. This is a cross jurisdictional program under the National Framework for Energy Efficiency and coordinated by the Department of Climate Change and Energy Efficiency. This program was introduced in 1999 and it is linked to the MEPS program.	Commenced October 1999 for some products and later for others. Ongoing.	http://www.energyrating.gov.au/man1.html
	Commonwealth	Commercial building disclosure	Under the program, most sellers or lessors of office space of 2000 square metres or more will be required to obtain and disclose an up-to-date energy efficiency rating.	Commenced November 2010.	http://cbd.gov.au/
	Commonwealth	National Carbon Offset Standard Carbon Neutral Program	This program allows the Australian operations of organisations or Australian products to be certified under the National Carbon Offset Standard (NCOS) as carbon neutral, meaning that net emissions associated with a product or an organisation's activities are equal to zero.	The NCOS commenced on July 2010 and will provide the functions of Greenhouse Friendly, which closed on June 2010.	http://www.climatechange.gov.au/government/initiatives/australian-carbon-trust/ncos-carbon-neutral-program.aspx
Advertising or educational scheme	Commonwealth	Clean Energy Investment Strategy	Strategy to attract investment into Australia's clean energy sector and assist Australian clean energy companies to access international markets through export and investment. The overall budget for this program is $14.9 million.	Runs from 2009-10 to 2011-12.	http://www.austrade.gov.au/14-9-million-for-clean-energy-trade-and-investment-Ministerial/default.aspx
	State	Renewable Energy Incentives Package (Queensland)	$0.22 million for the development of incentives and investment attraction for the renewable energy sector.	Committed.	http://www.cleanenergy.qld.gov.au/zone_files/Renewable_Energy/oce_rep_11_web_final.pdf
	State	Energy Conservation and Demand Management Package (Queensland)	$47.7 million for demonstration projects to reduce peak electricity demand, infrastructure investment and electricity price growth.	Commenced 2009-10.	http://www.climatechange.qld.gov.au/pdf/factsheets/1energy-b1.pdf
	State	Showcase renewable and energy efficient technologies (ACT)	Program to showcase low emissions or renewable energy technologies as an example of how individuals, property owners and businesses can adapt older buildings to reduce their energy impacts or incorporate energy efficient designs in new buildings.		http://www.environment.act.gov.au/climate_change/weathering_the_change
Broad target or intergovernmental framework	Commonwealth	National Waste Policy	Strategy 9 of the National Waste Policy is: 'The Australian Government, in collaboration with State and Territory Governments, will develop a strategy to address emissions from disposal of waste to landfill and other waste activities.' Strategies to address and/or offset emissions from waste and waste related activities are to be released by EPHC by 2011.	Runs from 2010 to 2015. National Waste Policy has been committed and specific actions are currently being developed.	http://www.environment.gov.au/wastepolicy/index.html
	State	Alternative Fuels Policy (Queensland)	The policy seeks to provide a framework for strategies which will encourage the continued development of alternative fuels.		http://www.sd.qld.gov.au/dsdweb/v4/apps/web/content.cfm?id=7564
	State	Clean Coal Victoria	Strategic and regional planning of coal resources, including future mines, infrastructure requirements, carbon storage, new technologies and future coal demands. The overall budget for this program is $12.2 million.	Runs from 2007-08 to 2010-11.	http://new.dpi.vic.gov.au/earth-resources/industries/coal/prospectivity/clean-coal-victoria

China

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Explicit carbon prices					
Emissions trading scheme - cap and trade			Some reports suggest that China is planning on trialling an emissions trading scheme (ETS) in a number of provinces as part of its 12th Five-Year Plan and that it will consider establishing a carbon trading market.		http://www.carbonpositive.net/viewarticle.aspx?articleID=2170 http://www.chinafaqs.org/blog-posts/chinas-party-plenum-recommends-climate-actions-12th-five-year-plan http://www.eco-business.com/news/2011/jan/10/china-moves-toward-carbon-emissions-trading-improv/ http://www.e3g.org/images/uploads/E3G_Chinese_Challenge_or_Low_Carbon_Opportunity.pdf http://www.pewclimate.org/international/factsheet/energy-climate-goals-china-twelfth-five-year-plan?utm_source=Pew+Center+on+Global+Climate+Change+newsletter+list&utm_campaign=8a44594af9-April_2011_Newsletter&utm_medium=email
Emissions trading scheme - voluntary			Several Chinese cities have implemented voluntary emissions trading schemes. These are the Beijing Environmental Exchange, the Tianjin Carbon Exchange and the Shanghai Carbon Exchange.	Commenced in 2009.	http://www.aph.gov.au/library/pubs/BN/eco/greenhouse.pdf http://www.chinadaily.com.cn/business/2008-10/27/content_7144537.htm http://www.cbeex.com.cn/article/en/ http://www.chinadaily.com.cn/bizchina/2009-04/17/content_7686605.htm
Carbon tax			Some reports suggest China is considering introducing a carbon tax. One report suggests a carbon tax will be imposed on industry in 2012, starting at CNY 20 (approximately $3) and rising to CNY 50 in 2020.		http://www.businessgreen.com/bg/news/1806070/reports-china-impose-carbon-tax-2012 http://www.chinaenvironmentallaw.com/2009/05/04/a-carbon-tax-in-china/ http://www.e3g.org/images/uploads/E3G_Chinese_Challenge_or_Low_Carbon_Opportunity.pdf
Subsidies and taxes					
Capital subsidy	National	Household Biogas Project	Assistance to eligible farmers for biogas digesters (conversion of biodegradable feedstock into energy). This is part of the renewable energy targets policy. In 2010, the Chinese Central Government provided financial support of CNY 5.2 billion to support the development of household and middle- and large-scale biogas project construction.	Commenced in 2006.	http://www.iea.org/textbase/pm/?mode=cc&id=3838&action=detail http://www.anaerobicdigestion.com/html/msw_biogas_plants_in_china.php
	National	Special funds for the industrialisation of wind generation equipment	Subsidy of 600 CNY/KW to any qualified wind power enterprise (applicable for the first 50 'wind power units'). This subsidy appears to be provided to manufacturers of wind generation equipment.	Commenced in 2008.	http://www.ccchina.gov.cn/WebSite/CCChina/UpFile/File571.pdf http://www.chinacsr.com/en/2008/08/25/2913-china-government-subsidizes-rd-on-wind-power/ http://www.cwpc.cn/cwpc/en/system/files/documents/Report_wind-power-price-policy_china.pdf http://www.mondaq.com/article.asp?articleid=81620
	National	Subsidy for Solar PV in Buildings	Subsidy of 20 CNY/W in 2009 for solar PV in buildings with the subsidy 'adjusted according to the development situation of the industry in the future'.	Commenced in 2009	http://www.ccchina.gov.cn/WebSite/CCChina/UpFile/File571.pdf http://www.reeep.org/file_upload/8_tmpphpJtRkvO.pdf
	National	The Golden Sun Demonstration Scheme	Subsidies for selected grid-connected solar PV projects (50 per cent of the capital investment) and off-grid solar PV projects (70 per cent of the capital investment).	Commenced in 2009	http://www.ccchina.gov.cn/WebSite/CCChina/UpFile/File571.pdf http://www.frankhaugwitz.info/doks/pv/2009_11_25_China_PV_Golden_Sun_SEMI.pdf http://www.chinafaqs.org/files/chinainfo/ChinaFAQs_Solar_Energy.pdf http://www.reeep.org/file_upload/8_tmpphpJtRkvO.pdf
	Sub-national	Subsidy for electric cars and hybrid cars	Subsidy of up to CNY 50 000 for the purchase of a plug-in hybrid vehicle (PHEV) and CNY 60 000 for an all-electric, or battery-electric vehicle (BEV). Some local governments also offer subsidies. In Hefei, BEV buyers can receive a CNY 10 000-20 000 local government subsidy and in Shanghai buyers can get CNY 40 000-50 000.	Commenced in 2009 and adjusted in 2010.	http://www.ccchina.gov.cn/en/NewsInfo.asp?NewsId=26551
	National	Efficient light bulb subsidy program	Provision of 50 million low-energy bulbs in 2008 and 100 million in 2009. Consumers pay half the price (agreed by manufacturers and government) and businesses pay 30 per cent of the price of globes.	Commenced in 2008.	http://www.chinadaily.com.cn/china/2009-02/25/content_7509138.htm http://www.iea.org/textbase/pm/?mode=cc&id=3971&action=detail http://www.reeep.org/file_upload/8_tmpphpJtRkvO.pdf

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	National	Subsidy for energy efficient household appliances	Subsidies for energy efficient air conditioners and other 'green' home appliances, such as fridges, televisions, washing machines and motors.	Runs from 1 June 2009 to 1 June 2011.	http://www.e-to-china.com/tariff_changes/Policy_Focus/2010/0511/78401.html http://pdf.wri.org/factsheets/factsheet_china_policy_2009-11-03.pdf
	Sub-national	Production subsidies for locally made wind turbines in Xinjian Uyghur	Up to 50 units can apply for an award of CNY 600 per kW. Renewable energy companies are also treated as high tech industries, enabling them to apply for an income tax reduction or exemption.	Commenced in 2008.	http://www.reeep.org/file_upload/8_tmpphpJtRkvO.pdf
	National	National Vehicle Subsidies (Vehicle Scrappage Scheme)	Financial incentives to scrap older or more polluting vehicles and to replace them with new vehicles.	The scheme ran from 1 June 2009 to 31 December 2010.	http://www.nytimes.com/2009/10/17/world/asia/17beijing.html?_r=2&hpw http://chinaautoweb.com/2010/05/chinas-cash-for-clunkers-program-to-be-extended-effects-disputed/ http://www.globalfueleconomy.org/Documents/Publications/wp1_asean_fuel_economy.pdf http://subscribers.wardsauto.com/ar/china_clunkers_september_101013/wall.html?return=http://subscribers.wardsauto.com/ar/china_clunkers_september_101013/ http://autonews.gasgoo.com/china-news/china-cash-for-clunkers-yields-250-000-sales-in-101011.shtml http://www.insideline.com/car-news/china-shanghai-residents-can-double-dip-with-cash-for-clunkers-subsidies.html
Feed-in tariff	National	Feed-in tariff (FIT) for wind turbines	FIT rates differ according to where the power is produced. There are four FIT zones, with rates varying from 0.51 CNY/kWh to 0.61 CNY/kWh (8–10 cents per kWh).	Commenced in 2003 (as the Wind Power Concession program).	http://www.reeep.org/file_upload/8_tmpphpJtRkvO.pdf
	National	Feed-in tariffs for biomass	From 2010, a FIT of 0.75 CNY/kwh was set for biomass power generation projects.	Commenced in 2006.	Ma (2011), http://www.reeep.org/file_upload/8_tmpphpJtRkvO.pdf
	Jiangsu	Jiangsu Feed-in Tariff for PV	The FIT rate for each kWh of electricity from PV solar farms, rooftop projects and BIPV projects was CNY 2.15, 3.7 and 4.3 respectively in 2009, 1.7, 3, and 3.5 in 2010 and 1.4, 2.4 and 2.9 in 2011. The objective of the policy is to have installed by the end of 2011 400 MW of solar PV capacity, comprising 260 MW from rooftop projects, 10 MW from BIPV projects and 130 MW from solar PV farms.	Commenced in 2009.	http://www.reeep.org/file_upload/8_tmpphpJtRkvO.pdf
	Inner Mongolia and Shanghai Chongmingdao	Feed-in tariff for grid connected PV	Feed-in tariff of 4 CNY/kWh for grid connected solar PV plant in Inner Mongolia (205kW) and Shanghai Chongmingdao (1 MW).	Commenced in 2008.	http://www.ren21.net/Portals/97/documents/Publications/Background_Paper_Chinese_Renewables_Status_Report_2009.pdf
Tax rebate or credit	Hong Kong	Tax incentives for environmentally friendly commercial vehicles	Reduction in the 'First Registration Tax' of between 30 and 100 per cent for vehicles sold with 'Environment-Friendly Commercial Vehicle Certificates'.	Commenced in 2008	http://www.iea.org/textbase/pm/?mode=cc&id=4192&action=detail
	National	Preferential tax policies for renewable energy.	Reduced income tax rates for foreign investment in biogas and wind production (15 per cent compared to 33 per cent). Other renewable energy projects can also apply for income tax rate reductions or exemptions. Wind turbines and their main components, as well as solar photovoltaic modules, also benefit from preferential customs duty rates.	Commenced in 2003 and expanded in 2007.	http://www.iea.org/textbase/pm/?mode=cc&id=3837&action=detail
	National	Reduced Valued Added Tax for renewable energy	In 2001, value added tax (VAT) for wind power was reduced from 17 per cent to 8.5 per cent. VAT refunds for the use of municipal solid waste for power generation were also implemented in 2001. In 2003, the VAT for biogas production was reduced to 13 per cent.	Commenced in 2001 (for wind) and 2003 (for biogas).	http://www.iea.org/textbase/pm/?mode=re&id=2247&action=detail
	National	Decreased export rebates for high energy consuming export products.	The Export tax rebate was reduced from 11 per cent to 8 per cent for steel, from 13 per cent to 8 per cent for cement, from 13 per cent to 11 per cent for glass and from 13 per cent to 5 per cent, 8 per cent or 11 per cent for some nonferrous metal products. In April 2007, the Government cancelled or cut to 5 per cent the tax rebates on exports of most steel products.	Commenced in September 2006.	http://china.lbl.gov/sites/china.lbl.gov/files/Overview.Energy_Policy_November2010.pdf
		Notice on adjustment of import tax policies for high-power wind turbine and its key parts and raw materials	Rules that import tax shall be collected for wind turbines of 2.5 MW or less to support local production.		http://www.ren21.net/Portals/97/documents/Publications/Background_Paper_Chinese_Renewables_Status_Report_2009.pdf
		Preferential tax rates for small hydro producers	Small hydro producers pay 6 per cent value added tax (VAT), rather than 17 per cent. In some counties the 25 per cent income tax rate is set at 0 per cent for SHPs while in other counties, it is set at 12.5 per cent.		http://www.ren21.net/Portals/97/documents/Publications/Background_Paper_Chinese_Renewables_Status_Report_2009.pdf
		Reduced taxes on Certified Emission Reductions (CERs) generated in renewable energy projects and revenue recycling to climate change projects	The sale of CERs through the Clean Development Mechanism (CDM) attracts different tax treatments depending on the type of project: 65 per cent of revenue from HFC and PFC projects; 30 per cent for N20 projects and 2 per cent for all other projects (mainly renewable energy). Revenues raised from this taxation is hypothecated to supporting climate change projects.		http://www.euchina-cdm.org/media/docs/Improvement%20of%20CDM%20Policies%20in%20China_EU%20China%20CDM%20Facilitation%20Project.pdf

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	National	Fuel Excise Exemption	Biodiesel and ethanol are exempt from fuel excise and a rebate is paid to producers for Value Added Tax (levied at 17 per cent). These exemptions only apply to authorised ethanol producers and to biodiesel producers that use at least 70 per cent recycled vegetable oil or tallow.	Commenced in 2010 (applying retrospectively from 2009).	
Tax exemption	National	Tax exemptions and preferential tax rates for energy savings companies (ESCos)	Companies involved in energy management projects receive temporary tax exemptions from Value Added Tax, Business Tax and Corporate Income Tax. Eligible companies are those that engage in energy management contracting projects.	Commenced in 2011.	http://www.china-briefing.com/news/2011/02/18/china-issues-preferential-taxation-policies-for-energy-saving-service-sector.html
Preferential, low-interest or guaranteed loan		Preferential taxation and loans for renewable energy projects	The Renewable Energy Law (see below) indicates that financial institutions may offer preferential loans for renewable energy exploitation and that the State may grant preferential taxation to projects listed in the 'development guidance catalogue' (Articles 25 and 26). The subsidy is a 2 percentage point interest rate discount.		http://www.npc.gov.cn/englishnpc/Law/2007-12/13/content_1384096.htm http://www.vivideconomics.com/docs/Vivid%20Econ%20Implicit%20Carbon%20Prices.pdf
	National	Restrictions on commercial loans to finance capacity expansion of enterprises suffering from overcapacity, backward production facilities, high-energy-consumption or high emissions.	The People's Bank of China and the China Banking Regulatory Commission jointly issued a circular, requiring commercial banks to curb lending to enterprises which consume high amounts of energy, those with high emissions, and industries with backward production facilities and over-capacity problems.	Circular issued 28 May 2010.	http://www.mondaq.com/article.asp?articleid=107502&login=true&nogo=1
Other subsidy or grant	National	Flexible Subsidies for Loss	Subsidies are provided to authorised ethanol producers to compensate for losses made in producing ethanol for road transport. The subsidy is based on an evaluation of each individual ethanol producer's annual financial performance.	Commenced in 2002.	
Fuel or resource tax	National	Vehicle excise tax rates	From September 2008, the excise tax rate for engines of 1.0L or less decreased to 1 per cent, and increased to 25 per cent for engines of 3.0 to 4.0L. The rate for cars with engines over 4.0L increased to 40 per cent.	Commenced in 2006 and amended in 2008 to current rates.	http://www.iea.org/textbase/pm/?mode=cc&id=4304&action=detail
	National	Vehicle purchase tax rates	In 2009, China halved the purchase tax rate on small engine vehicles (sub 1.6 litres) from 10 per cent to 5 per cent. However, it was raised to 7.5 per cent on 1 Jan 2010 and will return to 10 per cent in 2011.	Commenced in 2009.	http://www.vecc-mep.org.cn/eng/news/news_detail.jsp?newsid=41669
	National	Fuel excise	China taxes petrol and diesel at the national level through the 'Consumption Tax' at rates of CNY 1/L of petrol and CNY 0.8/L of diesel. There is no tax on LPG used as a transport fuel.		
Other tax	National	Electricity levy	Electricity surcharge to help fund the feed-in tariffs established under the Renewable Energy Law. The surcharge (electricity price increase) is levied on electricity users at a rate of 0.004 CNY/kWh in 2011.		http://beta.worldbank.org/reports/climate-change-and-fiscal-policy-report-apec http://www.ren21.net/Portals/97/documents/Publications/Background_Paper_Chinese_Renewables_Status_Report_2009.pdf
Regulatory instruments					
Renewable energy target	National	Renewable Energy Law/targets	Target to achieve 15 per cent non-fossil fuel energy by 2020 from wind, biomass, solar, and hydro-power (including specific targets for each source of generation). The Renewable Energy Law also requires all electricity grid companies to buy the power produced by renewable energy generators (Article 14) with penalties and compensation payable if renewable energy is not purchased by grid companies (Article 29). The Law was amended in 2009, primarily to expand the scope for renewable energy generation by grid companies and penalties for failure to purchase renewable energy.	Commenced in 2006	http://www.china.org.cn/english/environment/236955.htm http://www.iea.org/textbase/pm/?mode=cc&id=4129&action=detail http://www.iea.org/textbase/pm/?mode=cc&id=3836&action=detail http://www.chinaenvironmentallaw.com/2009/12/28/chinas-renewable-energy-law-amendments/ http://china.lbl.gov/sites/china.lbl.gov/files/LBNL-2860E.China_Energy_Primer.Nov2009.pdf http://www.reeep.org/file_upload/8_tmpphpJtRkvO.pdf http://www.iea.org/textbase/pm/?mode=cc&id=2246&action=detail
	National	Building Codes amended under the Renewable Energy Act	Under the Renewable Energy Law, buildings are encouraged to install solar water-heating systems, solar heating and cooling systems and solar photovoltaic systems. New buildings are also required to "provide the necessary conditions for the utilization of solar energy."	Commenced in 2006.	http://www.npc.gov.cn/englishnpc/Law/2007-12/13/content_1384096.htm Background paper: Chinese renewable status report 2009
	Local	Hebei Solar Building regulations	The city of Wuhan issued new regulations in 2008 that require all residential and government owned or financed buildings which are less than 12 storeys high to have a solar hot water heating system included in the design.	Commenced in 2008.	http://www.reeep.org/file_upload/8_tmpphpJtRkvO.pdf
Electricity supply or pricing regulation		Prohibition of the construction of new coal and gas fired units in industrial production	Article 33 of the Energy Conservation Law states that the 'building of new coal-fired or gasoline-fired generating units or new coal-fired thermal power generating units is prohibited'.	Commenced in 2007.	http://www.npc.gov.cn/englishnpc/Law/2009-02/20/content_1471608.htm

Policy type	Jurisdiction	Name	Description	Status and duration	References
	National	Closure of inefficient industrial facilities	Decommissioning of small and old industrial plants in the cement and steel sectors, chemical, refining, manufacturing, coking, glass, alumina and calcium carbide industries. According to the national report, these closures (in 2009) should amount to: 74.2 million tons of cement, 16.9 million tons of steel, 21.13 million tons of iron, 0.46 million tons of calcium carbide and 18.09 million tons of coking. In 2008, the Central Government provided 6.2 billion Yuan to help resettle employees and change the line of production for affected facilities.	Commenced in 2007	http://www.iea.org/textbase/pm/?mode=cc&id=4306&action=detail http://www.ccchina.gov.cn/WebSite/CCChina/UpFile/File571.pdf http://china.lbl.gov/sites/china.lbl.gov/files/ACEStudy.2011.pdf
	National	Closure of inefficient power plants (Large Substitute for Small program)	Decommission of small and inefficient power generators and acceleration of advanced energy generation technology (super critical and ultra super critical). Some compensation is payable and reduction quotas are in place at the provincial and regional levels. Focus in 2011 is on plants with less than 100 MW units and after this, plants up to 200 MW will be targeted.	Commenced in 2006	http://www.iea.org/textbase/pm/?mode=cc&id=4306&action=detail http://www.ccchina.gov.cn/WebSite/CCChina/UpFile/File571.pdf http://pdf.wri.org/china_united_states_climate_change_challenge.pdf http://www.iea-coal.org.uk/publishor/system/component_view.asp?LogDocId=82268&PhyDocID=7430 http://www.adb.org/Documents/Working-Papers/2008/How-PRC-Pursuing/How-PRC-Pursuing.pdf http://pdf.wri.org/factsheets/factsheet_china_policy_2009-11-03.pdf
		Encouragement of advanced coal technologies	The energy conservation power generation scheduling program gives efficient units a higher place in the merit order, and this will drive supercritical and USC plants to be given preference as new capacity is added.		http://pdf.wri.org/factsheets/factsheet_china_policy_2009-11-03.pdf http://www.vivideconomics.com/docs/Vivid%20Econ%20Implicit%20Carbon%20Prices.pdf
		Differential electricity pricing for high-energy consuming industries.	For some industries, electricity prices are set based on their emissions intensity. These industries include electrolytic aluminium, ferroalloy, calcium carbine, caustic soda, cement, and steel. Rates vary according to the level of energy efficiency, where industries are categorised as either 'encouraged', 'permitted' 'restricted' or 'eliminated'. Enterprises in the 'encouraged' and 'permitted' category pay the standard price of electricity in their area while 'restricted' and 'eliminated' enterprises pay a surcharge.	Commenced in 2004.	Zhou et al 2010, Overview of current energy efficiency policies in China Energy Policy 38, pp. 6439-6452.
Technology standard	National	Efficiency upgrade for electric motors	Nationwide mandated efficiency improvements. These include the promotion of highly efficient electrical motors and the renovation of pumps and compressors.	Commenced in 2006	http://www.iea.org/textbase/pm/?mode=cc&id=2520&action=detail
Fuel content mandate	National	Vehicle fuel economy standards	Maximum allowable fuel efficiency standards (both passenger and light commercial vehicles). There are 16 categories based on weight and additional categories for manual or automatic transmission. In 2009, China issued its proposed Phase III fuel consumption regulation for passenger cars, aimed at reducing the fuel consumption of new passenger vehicles to 7l/100km (167 gCO2/km) by 2015.	Commenced in 2005 for passenger vehicles (and amended in 2008 to include light commercial vehicles). Further changes were foreshadowed in 2009.	http://www.iea.org/textbase/pm/?mode=cc&id=4305&action=detail http://www.theicct.org/2010/04/ghg-fe-standards-update/ http://belfercenter.ksg.harvard.edu/publication/19690/chinas_fuel_economy_standards_for_passenger_vehicles.html http://news.xinhuanet.com/english/2009-07/30/content_11799689.htm http://english.gov.cn/2009-08/13/content_1391467.htm
	Sub-national	National Scheme of Extensive Pilot Projects on Bioethanol Gasoline for Automobiles	Petrol is required to contain 10 per cent ethanol in six provinces (Heilongjiang, Jilin, Liaoing, Henan, Guangxi and Anhui), nine cities in Hubei province, seven cities in Shandong province, six cities in Hebei and five cities in Jiangsu. Only authorised ethanol producers are able to supply ethanol under this program.	Commenced in 2004.	Dong (2007)
Energy efficiency regulation	National	Minimum energy performance standards	Appliance standards (minimum energy performance standards) and energy efficiency labelling for a range of household appliances.		http://china.lbl.gov/sites/china.lbl.gov/files/ACEStudy.2011.pdf
	National	Efficiency upgrade for appliance production and public lighting.	Promotion of high efficiency lighting systems in public facilities, hotels, shopping centres, office buildings, and sports venues; and the 'renovation' of production and assembly lines of high efficiency electronic appliances.	Commenced in 2006	http://www.iea.org/textbase/pm/?mode=pm&id=2523&action=detail
		Phasing out of incandescent lamps (ILs)	Phasing out the production of high energy using incandescent (ILs) lamps and supporting the transition of IL manufacturers to energy saving lamps. The program is also supported by an awareness raising campaign.	Commenced in 2008 with phase out to be completed by 2012.	http://www.undp.org.cn/projects/00062179.pdf http://www.npc.gov.cn/englishnpc/Law/2009-02/20/content_1471608.htm
	National	National Building Codes (Civil Building Energy Conservation Ordinance 2008)	Requirement for a 50 per cent reduction in the 'total operation load' of buildings (in some cases, large cities have required a 65 per cent reduction) based on average energy consumption in the 1980s. This is calculated using average consumption by building type within designated climate zones. This ordinance applies to residential, commercial and public buildings.	Commenced in 2008	http://www.iea.org/textbase/pm/?mode=cc&id=4307&action=detail http://www.iea.org/textbase/pm/?mode=pm&id=2522&action=detail http://china.lbl.gov/sites/china.lbl.gov/files/ACEStudy.2011.pdf
	National	Retrofitting Buildings	Target for retrofitting 150 million square metres of floor area to realise a 50 per cent heating intensity reduction by the end of 2010. This is an aspect of the 11th Five-Year plan	Commenced in 2006	http://china.lbl.gov/sites/china.lbl.gov/files/ACEStudy.2011.pdf
	Shandong Province	Shandong Province One Million Rooftops Sunshine Plan	Program designed to stimulate the use of renewable energy sources in building construction, especially solar power and geothermal power. The program includes compulsory regulations for the cities of Yantai and Jinan, for the integration of solar energy in the construction and design of certain buildings.	Commenced in 2008	http://www.iea.org/textbase/pm/?mode=re&id=4133&action=detail

Policy type	Jurisdiction	Name	Description	Status and duration	References
	National	Conversion of exhaust heat and pressure	Mandated efficient use of exhaust, pressure and heat from mining and industrial processes (iron and steel).	Commenced in 2006 (appears to be operational over the 11th five year plan period 2006-2010).	http://www.iea.org/textbase/pm/?mode=pm&id=2518&action=detail
	National	Aluminium industry permitting standards	Standards covering a range of parameters including energy consumption, plant size, and technology. They apply to bauxite mines, alumina refineries, primary aluminium smelting operations, secondary aluminium and aluminium processing plants. In principle, they have the effect of not allowing the construction and expansion of aluminium projects with redundant capacity.	Commenced in 2007	http://www.iea.org/textbase/pm/?mode=cc&id=4308&action=detail
	National	Efficiency upgrade for coal burning industrial boilers and kilns	This scheme contains the following three measures: (1) selection of high quality coal; (2) renovation of small and medium sized boilers and kilns; and (3) establishment of scientific management and operation systems.	Commenced in 2006	http://www.iea.org/textbase/pm/?mode=cc&id=2516&action=detail
Mandatory assessment, audit or investment	National	Enhanced Efficiency Monitoring and Auditing: Development of Efficiency Centres	Efficiency centres are required to develop and provide 'efficiency diagnosis, design, financing, renovation, operation and management' for businesses, government institutions and schools.	Commenced in 2006	http://www.iea.org/textbase/pm/?mode=pm&id=2525&action=detail
Urban or transport planning regulation	National	Low carbon zones	Development of low carbon zones in eight cities and five provinces, covering 300 million people. Modelled on the Special Economic Zones of the 1980s, these zones would allow more freedom to experiment with low carbon policy in exchange for committing to higher emission targets.		http://www.e3g.org/images/uploads/E3G_Chinese_Challenge_or_Low_Carbon_Opportunity.pdf http://www.chathamhouse.org.uk/research/eedp/current_projects/china_lcz/
Other regulation	Local - Beijing	Vehicle licensing lotteries	Beijing introduced a monthly lottery scheme in 2011 to allocate licences to operate a vehicle in the city. The scheme caps the number of new licences issued at 240 000 per year in an effort to reduce pollution and congestion. Driving in the city at peak times requires a Beijing license plate.	Commenced in 2011.	http://www.china.org.cn/business/2011-01/09/content_21700508.htm http://www.iied.org/sustainable-markets/blog/braking-beijing%E2%80%99s-car-addiction
	Local - Shanghai	Vehicle licensing auction	Shanghai holds a monthly auction for vehicle licenses. The scheme previously used fixed prices, but since 2000, it has used an open auction.	Started in mid 80s and revised in 2000 to an open auction. It is ongoing.	http://www.worldenergy.org/documents/annex_6_shanghai_1.pdf http://dengruo.info/201012/license-plate-auction-shanghai-government-blocking-ace/
Direct government expenditure					
Government procurement - general	National	Energy efficiency products for government procurement	Publication of a list of energy efficient products for public procurement including refrigerators, air conditioners, televisions and computers. All government agencies must give priority to products on the list.	Commenced in 2006	http://www.iea.org/textbase/pm/?mode=cc&id=2515&action=detail http://www.npc.gov.cn/englishnpc/Law/2009-02/20/content_1471608.htm
	National	Energy conservation in government	During reconstruction of government buildings, 20 per cent of the total construction area must meet the national building energy efficiency standard. Government procurement must also promote high efficiency products and publish a list of these products (see above policy item). Government vehicle purchases must focus on 'low-oil-consuming' vehicles.	Commenced in 2006 (appears to be operational over the 11th five year plan period 2006-2010).	
Government procurement - infrastructure	National	Expansion of local co-generation	To improve the efficiency of heating, the Government has invested in high efficiency co-generation facilities and transformed existing coal burning small boilers.	Commenced in 2006	http://www.iea.org/textbase/pm/?mode=cc&id=2517&action=detail
	National	Brightness Rural Electrification Program	Umbrella program (including sub programs) to facilitate the electrification of rural communities. It includes wind and solar programs.	Commenced in 1996	http://www.iea.org/textbase/pm/?mode=cc&id=2245&action=detail http://www.nrel.gov/docs/fy04osti/35790.pdf
		New Energy Industry Development Plan, 2011-2020	The Government plans to invest CNY 5 trillion in the 'new energy sector' over the period 2011 to 2020, including CNY 2-3 trillion in renewable energy (of which CNY 1.5 trillion is for wind and CNY 200-300 billion is for solar).	Commenced in 2011.	http://www.e3g.org/images/uploads/E3G_Chinese_Challenge_or_Low_Carbon_Opportunity.pdf
		Energy-Saving and New Energy Vehicle Industry Development Plan	Government plans to invest CNY 100 billion in the alternative energy vehicles industry in the period 2011-2020.	Commenced in 2011.	http://www.e3g.org/images/uploads/E3G_Chinese_Challenge_or_Low_Carbon_Opportunity.pdf
	Local - Hangzhou	Bicycle Rental Scheme	The Hangzhou Bicycle Rental Company (HBRC), a state-owned enterprise initially supported by local financing, has developed a rental business in Hangzhou, capital of the Zhejiang province. The scheme has 2000 rental stations with 50 000 bicycles.		http://www.theclimategroup.org/_assets/files/China-Clean-Revolution-III.pdf
Government procurement - environment	Guangxi Province	Guangxi Province 1 Million Mu Bio-Fuel Forest Project	Plan to develop a 1 million Mu (approximately 165 00 acres) 'Jatropha' tree forest. The forest is estimated to yield over 160 000 MT of biodiesel, worth CNY 640 million. This is a joint project between Guangxi Zhilian Renewable Energy Co. Ltd. and the Guangxi Forestry Science and Technology. CNY 500 million is budgeted for the development of the jatropha forest and CNY 200 million for the construction of a biodiesel refinery and production lines for related products.	Commenced in 2008	http://www.iea.org/textbase/pm/?mode=re&id=4132&action=detail
Support for research and development					

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
R&D - general and demonstration		Funding for science and technology	Funding for science and technology with a key emphasis on research regarding technologies that can reduce greenhouse gas emissions. By the end of 2007, the National Science and Technology Plan for the 11th Five-Year Plan period (2006-2010) had appropriated more than CNY 7 billion for scientific research into energy conservation and emission reduction.		http://english.gov.cn/2008-10/29/content_1134544_6.htm http://www.chinafaqs.org/library/chinafaqs-emerging-revolution-clean-technology-research-development-and-innovation-china
		R&D funding under the Renewable Energy Law	Under the Renewable Energy Law, a specific fund was set up 'for developing renewable energy to support the evaluation and investigation of renewable energy resources, related technological research and development, construction of pilot and demonstration projects, and the development and utilization of renewable energy in the countryside'.		
	National program implemented in selected cities	City of One Thousand Ten project - to promote the use of 'new energy' vehicles in public transport and public sector	Each year, ten cities will launch 1000 'new energy' vehicles as demonstrators to promote hybrid, electric, and energy-efficient vehicles for taxi, bus, sanitation and post office use. Local governments will apply for funding based on a promotion plan.	Commenced in 2009 with an expected duration of 3 years.	http://www.china5e.com/show.php?contentid=156687 http://www.vecc-mep.org.cn/eng/news/news_detail.jsp?newsid=38199 http://www.car-word.info/ten-city-one-thousand-to-accelerate-the-industrialization-of-electric-vehicles-in-china
Other					
Labelling scheme	National	Energy efficiency labelling	15 product categories (as of 2009) are subject to energy efficiency labelling (primary residential products including refrigerators, air conditioners, washing machines and heaters).	Commenced in 2005 (with various appliances added over the period to 2009).	http://www.ccchina.gov.cn/WebSite/CCChina/UpFile/File571.pdf http://www.npc.gov.cn/englishnpc/Law/2009-02/20/content_1471608.htm
	Sub-national	Vehicle labelling scheme (primarily aimed at air quality improvement but measures are driving older vehicles to be removed and replaced with new ones).	The Ministry of Environmental Protection is using coloured labels to identify high and low emitting vehicles. Older vehicles introduced prior to tailpipe emissions standards have to display a yellow label. Low emitters display a green label. The initiative initially targets certain areas. In August 2009, a circular stated MEP will work with six regions, including Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, and Shandong, on making a regional air pollution control plan and environment management policy to promote the improvement of air quality in these regions.	Commenced in 2009.	http://www.chinacsr.com/en/2009/08/03/5811-mep-tightens-up-on-environmental-labels-for-vehicles/ http://english.gov.cn/2009-08/13/content_1391467.htm http://www.vecc-mep.org.cn/eng/news/news_detail.jsp?newsid=41876 http://www.vecc-mep.org.cn/eng/news/news_detail.jsp?newsid=40395
Advertising or educational scheme	National	Green Education and dissemination	Article 8 of the Energy Conservation Law 2008 says that 'The State shall disseminate knowledge about energy conservation and educate people in this respect, include such knowledge in the system of national education and training, spread the scientific knowledge about energy conservation and enhance the awareness of the importance of energy conservation among all the people, and advocate an economical pattern of consumption.'	Commenced in 2008.	http://www.npc.gov.cn/englishnpc/Law/2009-02/20/content_1471608.htm
Broad target or intergovernmental framework		Australia-China Bilateral Cooperation on Climate Change (MOU)	The Memorandum of Understanding (MOU) sets out cooperation in climate change policies and impacts and adaptation; national communications (greenhouse gas inventories and projections); technology cooperation, capacity building and public awareness. It also includes 'Pursuing Renewable Energy Business in China: A Guide for Australian Companies Doing Business in China' and two handbooks on renewable energy capacity and Australia's energy efficiency capabilities.	Signed in 2003.	http://www.iea.org/textbase/pm/?mode=cc&id=1332&action=detail http://www.foreignminister.gov.au/releases/2004/fa122_04.html
		Australia-China MOU on energy resources cooperation	MOU between the Department of Resources, Energy and Tourism of Australia and the National Energy Administration of the People's Republic of China on enhancing cooperation in the field of energy.	Signed in June 2010.	http://pmrudd.archive.dpmc.gov.au/node/6833
		Australia-China joint study for commercial scale CCS project	Cooperation on a joint feasibility study for a commercial scale carbon capture and storage project in China. Australian Government funding amounts to $12 million.	Announced 17 December 2010.	http://minister.ret.gov.au/MediaCentre/MediaReleases/Pages/AustraliaChinaJointStudyForCommercialScaleCCSProject.aspx
		US-China Biomass Development	The MOU was signed in 2007 by the US Department of Energy and Department of Agriculture, together with China's National Development and Reform Commission. The MOU outlines cooperative efforts between the two countries, focusing on the exchange of scientific, technical, and policy information on biomass production and its conversion into biofuels.	Signed in 2007.	http://www.iea.org/textbase/pm/?mode=re&id=3833&action=detail
	National	11th Five-Year Plan (2006-2010)	Sets out a wide range of measures and plans for the economy to reduce its energy intensity by 20 per cent between 2005 and 2010 (4 per cent per year). This is part of a broader goal of quadrupling economic growth and only doubling energy consumption between 2000 and 2020. The target has been allocated among industrial sectors and provinces.	Commenced in 2006.	http://www.iea.org/textbase/pm/?mode=cc&id=4310&action=detail http://www.ieej.or.jp/aperc/CEEP/CEEP-all.pdf http://www.cciced.net/encciced/events/agm/AGMFour/2010AGM/doc2010/201011/P020101112422281888606.pdf http://www.e3g.org/programmes/europe-articles/february-european-council-set-to-let-china-overtake-eu-on-clean-energy-inno/

Policy type	Jurisdiction	Name	Description	Status and duration	References
	National	12th Five-Year Plan (2011-2015)	The 12th Five Year Plan adopts a number of targets relating to energy and climate change and includes a goal to 'gradually establish a carbon trade market'. Targets include: - A 16 percent reduction in energy intensity (energy consumption per unit of GDP) - Increasing non-fossil energy to 11.4 percent of total energy use - A 17 percent reduction in carbon intensity (carbon emissions per unit of GDP).	Commenced in 2011.	http://www.pewclimate.org/international/factsheet/energy-climate-goals-china-twelfth-five-year-plan?utm_source=Pew+Center+on+Global+Climate+Change+newsletter+list&utm_campaign=8a44594af9-April_2011_Newsletter&utm_medium=email http://www.e3g.org/programmes/europe-articles/february-european-council-set-to-let-china-overtake-eu-on-clean-energy-inno/ http://www.e3g.org/images/uploads/E3G_Chinese_Challenge_or_Low_Carbon_Opportunity.pdf
		United Nations Framework Convention on Climate Change (Copenhagen Accord pledges).	As part of the Copenhagen Accord, China stated that it would 'Endeavour to lower its carbon dioxide emissions per unit of GDP by 40-45 per cent by 2020 compared to the 2005 level, increase the share of non-fossil fuels in primary energy consumption to around 15 per cent by 2020, increase forest coverage by 40 million hectares and increase forest stock volume by 1.3 billion cubic metres by 2020 compared to 2005 levels.'	Commenced in 2009.	http://www.climatechange.gov.au/government/initiatives/~/media/publications/committee/international-climate-change-policies-pdf.ashx http://unfccc.int/meetings/cop_15/copenhagen_accord/items/5265.php
Voluntary agreement		Top 1000 industrial energy conservation program	Program to reduce the energy use of China's top 1000 industrial companies. The program covers a range of sectors and establishes 5-year goals for companies to reach advanced domestic or international levels. The focus of the program during the 11th five year plan period was to help achieve the Government's energy intensity targets.	Commenced in 2006.	http://www.iea.org/textbase/pm/?mode=cc&id=3542&action=detail http://china.lbl.gov/sites/china.lbl.gov/files/ACEStudy.2011.pdf

Germany

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Explicit carbon prices					
Emissions trading scheme - cap and trade	Eurporean Union. Member state governments (including Germany) have responsibilities for administering the EU ETS (including free	European Union Emissions Trading Scheme (EU ETS)	Electricity generators (and firms in some other sectors) are required to surrender one European Union Allowance (EUA) for each tonne of carbon dioxide they emit. EUAs are internationally traded permits. In the second phase of the European Union ETS (2005–2008), the majority of permits were allocated to firms with ETS obligations. However, during this period around 9 per cent of Germany's allocation of EUAs were auctioned by the German Government. This is scheduled to increase to 70 per cent by the end of the third phase (2010–2020). The scheme does not currently cover road transport fuels but will cover aviation fuels from 2012, with around 85 per cent of permits to be allocated to firms in that year.	The scheme has been in operation since 2005. The second phase of the EU ETS has been underway since January 2008. The EU Directive for phase III of the EU ETS entered into force in June 2009.	
Subsidies and taxes					
Capital subsidy	National	Combined Heat and Power Act	Subsidies to builders of networks for the transmission of heat. The purpose of the Act is to contribute to increasing the proportion of electricity that is generated using combined heat and power to 25 per cent. Combined heat and power generation is less emissions-intensive than conventional thermal electricity generation. Subsidies are limited to 20 per cent of total project costs, and a maximum of €5 million per project. Annual costs of this part of the policy are not to exceed €150 million.	The amended Act on the Preservation, Modernisation and Development of Combined Heat and Power Generation was promulgated in the Federal Law Gazette of 31 October 2008, after which it immediately entered into force. The support will apply to new networks becoming operational before 31 December 2020.	http://bundesrecht.juris.de/kwkg_2002/__7a.html; http://www.umweltdaten.de/publikationen/fpdf-l/3517.pdf and http://bundesrecht.juris.de/kwkg_2002/BJNR109200002.html
	National	Market Incentive program	A scheme to support the deployment of heat from renewable energy sources. It consists of upfront investment support (provided by the Federal Agency for Industry and Export) and subsidised loans plus repayment assistance (provided by the Bank for Reconstruction (KfW)). The level of investment support and repayment assistance varies with th size of plant and by technology. The criteria changed in 2010 (after the programme was resumed in July 2010, following its temporary suspension in May 2010), making renewable-sourced heat in newly-constructed housing ineligible (since the Renewable Energies Heat Act of 2009 made a minimum usage of renewable energy sources for heat mandatory when planning new houses). An exception is made for plants that significantly exceed the minimum standards required by the Renewable Energies Heat Act. Renewable-sourced heat in existing housing stock is still eligible. €500 million per annum are available for this scheme. In 2010, the uptake was €235 million in investment support and €105 million in repayment assistance.	The program was initiated in 2000, temporarily suspended in May and June 2010, and resumed in July 2010. Funding is confirmed up to (and including) 2012.	http://www.erneuerbare-energien.de/files/pdfs/allgemein/application/pdf/map_waerme_2010juli_bf.pdf and http://www.erneuerbare-energien.de/inhalt/46982/4590/ and http://www.fichtner.de/pdf/MAP-Evaluationsbericht_2009.pdf and http://www.umweltdaten.de/publikationen/fpdf-l/3517.pdf
	Baden-Württemberg	Demonstration projects for efficient energy use and improved usage of renewable energies	This project supports innovative technologies or plants that substantially lower energy usage compared to the state of the art or improve the use of renewable energies. The grant covers a maximum of 40 per cent of project costs.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=222
	Bavaria	Demonstration project for the extraction of energy from biomass	The program supports pilot projects using biomass for the production of heat or electricity. The project needs to be ecologically and economically viable. The grant can cover up to 30 per cent of eligible project cost (up to 40 per cent for SMEs).	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10954
	Bavaria	Support for Biomass Heating for the Avoidance of CO2 Emissions	This program supports biomass heating plants that are projected to abate more than 500 tonnes of CO2 in 7 years. The plant must be located in Bavaria. The grant is set at €20 per tonne of CO2 abated per year, with a cap of €200 000 or 30 per cent of eligible costs.	Ongoing. The ordinance expires on 31 December 2012.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10702
	Bremen	Replacement of Electric Heaters	Supports the replacement of electric heaters in residential and commercial buildings in Bremen. The amount granted depends on the kind of replacement and the kind of property.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=7368
	Bremen	Usage of Wind Energy in Bremen	This program supports the construction of wind energy in Bremen. The turbines must be connected to the grid, available on the market, and make economic sense. Electricity from these turbines must not be sold as 'green electricity' for at least 12 years after construction has been finished. The size of the grants varies, but is set 'such that over 12 years, and taking the expected wind into account, the plant will finance itself'.	Expired on 28 February 2011.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=8163
	Hamburg	Support program Bio-energy	This program supports the construction of bio-energy plants. Private persons and firms with property in Hamburg are eligible. Heating plants up to 500 kW capacity receive €30 per kW if newly constructed, or €45 if the plant is being re-tooled. For larger plants the grant is decided on a case-by-case basis	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=9400
	Hamburg	Support Ordinance Renewable Energies	This ordinance supports selected renewable technologies, including biomass and photovoltaic. The size of the grant depends on the project, in particular on the type of technology used and the abatement achieved.	Ongoing. The ordinance is set to expire on 31 December 2013.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10888
	Hamburg	Climate Protection program - Solar heat and heating	Supports the installation of solar heating, and the replacement of existing heating with energy-efficient heating. Grants are €100 per square meter of solar receptors up to 30 square meters, and €60 for larger installations.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=9408
	Hamburg	Climate Protection program - heat insulation in existing buildings	Supports the insulation of existing buildings (both residential and commercial). Grants depend on the area insulated, and will be doubled if annual heating energy required has dropped by more than 50 per cent as a result. Particularly innovative technologies are also eligible for extra funding, which is determined on a case-by-case basis. Funding must not exceed €100 000 per annum.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=8370

Policy type	Jurisdiction	Name	Description	Status and duration	References
	Nordrhein-Westphalen	Progres. NRW - Market Incentivisation Part	This program supports investments in a wide variety of renewable energy and energy efficiency technologies. Funding covers up to 30 per cent of eligible costs (up to 40 per cent for solar and 'exceptional' projects).	Applications for support are to be handed in from 14 February 2011 until 13 October 2011. A similar program is likely to be established for 2012.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=9579
Feed-in tariff	National	Renewable Energy Sources Act (EEG)	The act applies to operators generating electricity from renewable energy sources and mine gas. Grid system operators are obliged to give such generators priority connection to electricity grids, and purchase and transmit all the electricity they generate. Under the Act, grid system operators are obliged to pay minimum fees (that is, feed-in tariffs) to renewable and mine gas electricity generators. The minimum fees are set out in the Act. For each eligible energy source, there is a range of fees, depending on the size of the generator. Smaller installations are paid a higher fee per kilowatt hour of electricity produced. The highest feed-in tariff is applicable to solar photovoltaic systems with a capacity of less than 30 kilowatts (€0.574 per kilowatt hour). There are provisions in the Act for the feed-in tariffs to be reduced over time.	Germany has paid feed-in tariffs to renewables since 1990. The latest revision of the Act came into force on 1 January 2009.	http://www.umweltdaten.de/publikationen/fpdf-l/3517.pdf
	National	Combined Heat and Power Act	Operators of cogeneration systems receive a payment for every kilowatt hour of electricity they produce. Smaller plants are eligible for higher subsidies. The support for larger plants is limited to plants being highly efficient and becoming operational before 31 December 2016. €750 million per year has been earmarked for financial support for CHP-generated electricity and heat grids, of which up to €150 million is dedicated for the construction of heat grids.The money is raised through a levy on electricity, which is discounted for large consumers and energy-intensive companies.	The amended Act on the Preservation, Modernisation and Development of Combined Heat and Power Generation (Combined Heat and Power Act) was promulgated in the Federal Law Gazette of 31 October 2008, after which it immediately entered into force.	http://www.eeg-kwk.net/de/file/KWK-G_JA2009-WP_Internet.pdf and http://www.umweltdaten.de/publikationen/fpdf-l/3517.pdf
Tax rebate or credit	National	Introduction of Modern Energy Management Systems	Companies in the manufacturing, agriculture and forestry sectors receive reductions in the taxes they pay on electricity and heating fuels. This measure proposes that eligibility for tax concessions will be linked to the company having a modern energy management system, which is a plan to improve energy efficiency.	No relevant supporting measures have been implemented to date. A government-industry agreement is being sought by 2013 on the use of energy management systems as a prerequisite for granting reduced energy taxation rates. A draft timetable included in the Integrated Energy and Climate Program envisages a systematic collection of firm-level energy data starting in 2011, an introduction of energy-management structures in 2012, and a binding agreement by 2013. It appears that the government is running behind this schedule.	IEKP 2007 and http://www.umweltdaten.de/publikationen/fpdf-l/3517.pdf
Tax exemption	National	Fuel Tax Exemption for Pure and Blended Biofuels	iodiesel and vegetable oil are partially exempt from fuel taxes, with the exemption equivalent to €0.2734/L and €0.3049/L in 2009. The ethanol component of petrol blends (that contain at least 70 per cent ethanol) and 'cellulosic ethanol' are fully exempt.	Ongoing.	http://ec.europa.eu/environment/enveco/taxation/pdf/Annex%205%20-%20Calculations%20from%20the%20case%20studies.pdf
	National	Electricity Tax Exemption	Germany has an electricity excise of €0.0205 per KWh. Electricity used in manufacturing, agriculture and forestry is taxed at a lower rate (€0.0123 cents) and elctricity used by buses and railways is taxed at €0.0114 cents. Electricity from wind, solar, geothermal, small hydroelectric, biomass, landfill or sewage gas is exempt from the tax.	Ongoing.	OECD (2010), Taxation, innovation and the environment, p. 55.
Preferential, low-interest or guaranteed loan	National	Special program - Offshore Wind	A €5 billion loans program administered by the state-owned Kreditanstalt fur Wiederaufbau (KfW) (the Bank for Reconstruction) will be launched in 2011. It will target offshore wind, and is supported by measures to reduce investment hurdles and improve grid access. The aim is to finance the first 10 offshore wind parks. The government states that loans will be made available at market interest rates.	The program was announced off the back of the Energy Concept 2050 (released in September 2010). The planned launch is 2011.	http://www.bmu.de/energiekonzept/doc/46497.php
	Baden-Württemberg	Agriculture and Food Industry Environmental and Customer Protection	SME food and agricultural companies are eligible for soft loans up to €10 million for any project that reduces energy consumption (in the food industry), reduces emissions (food industry and agriculture), or improves customer protection. Only projects located in Baden-Württemberg are eligible	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10375
	Baden-Württemberg	Agriculture - Sustainability	This program supports investments to reduce emissions or raise energy efficiency, for SMEs engaged in agricultural production and located in Baden-Württemberg. Loans cover up to 100 per cent of eligible investment costs, but no more than €10 million per year.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10314
	Baden-Württemberg	New Energy - Energy from the Countryside	This program supports SME energy producers. It provides loans covering up to 100 per cent of eligible investment costs, up to €10 million per year, for investments in biomass, photovoltaic, wind and hydro energy.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10351
	Baden-Württemberg	Environmental Protection And Energy Saving program	A program for SMEs. It supports investment in energy saving projects, projects that reduce pollution emmissions, and programs that reduce the amount of sewage resulting from production processes. Loans cover up to 75 per cent of eligible costs. Loan guarantees are available, but conditions are not made explicit.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=7721
	Baden-Württemberg	Sustainable Living: Renewable Energies	This program only applies to private residential properties located in Baden-Württemberg, and supports the installation of renewable energies and combined heat and power heating. Up to 100 per cent of eligible project costs are covered, the loans range from a minimum of €5000 to a maximum of €50 000.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=9834

Policy type	Jurisdiction	Name	Description	Status and duration	References
	Bavaria	Bavarian Modernisation program	This program supports the renovation of rental flats and care homes. Eligible are houses that are at least 15 years old, house at least 3 flats or 8 care rooms. The loan covers up to 100 per cent of the renovation costs.	Ongoing. The program is set to expire on 31 December 2011.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=8207
	Bavaria	Bavarian Eco-credit	This program supports conservation and environmental protection measures, including sewage filtering, clean air measures, noise pollution reduction measures, usage of renewable energies and energy efficiency measures. SMEs with a location in Bavaria are eligible. Climate protection measures can receive up to 80 per cent of eligible costs as a loan, all other measures up to 50 per cent. Minimum project costs are €25 000, and maximum costs are €12.5 million. The loan must not exceed €1 million (though exceptions are made).	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=9079
	Bavaria	Support for Geothermal Heat Grids	This program supports the construction of heat grids (in addition to support that is available through federal funding), provided the majority of transported heat is from geothermal sources. Only projects located in Bavaria and receiving Bank for Reconstruction (KfW) funding are eligible. Support can be either a loan or a grant. Grants are €60 per metre of grid (for a throughput of 0.5-1.5 MWh), €40 per metre (for a throughput of 1.5-3 MWh), up to a maximum of €1.5 million. A loan can cover up to 50 per cent of eligible costs, up to a maximum of €10 million.	Ongoing. The ordinance expires on 31 December 2011.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10701
	Berlin	Energetic Renovation	The Investitionsbank Berlin provides low-interest loans for the energy-efficient renovation of buildings. Only buildings constructed or permitted before 1 January 1995 are eligible. Loans cover 100 per cent of renovation costs up to €50 000 per flat.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=9823
	Berlin	Wohnraum Modernisieren (Modernising Living Spaces)	The Investitionsbank Berlin, in collaboration with Bank for Reconstruction (KfW) supports the renovation of rental housing. This covers both general renovations and energy-efficiency measures (for example, as mandated by the Federal Energy Saving Ordinance). Low-interest rate loans cover up to 100 per cent of eligible investment costs, but no more than €100 000 per flat, or €50 000 per flat for energy-efficiency measures. Loans from this program can be combined with other support measures.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=9827
	Brandenburg	Brandenburg-loan for Rural Areas	This program covers a wide variety of investments in rural Brandenburg, including renewable energies and biomass projects. SMEs are eligible for up to 100 per cent of project costs, but no more than €10 million per year.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=9822&pos=anlage5#anlage5
	Brandenburg	Brandenburg-loan for Municipalities	In collaboration with Bank for Reconstruction (KfW) the Brandenburg State Investment Bank is supplying subsidised loans to municipalities intending to renovate their buildings in order to reduce CO2 emissions. Only schools, school gyms, kindergardens, nurseries and youth centres built before 1 January 1990 are eligible. Renovations up to the state of the art are eligible for up to €300 per square meter, other renovations up to €200 per square meter.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=9675
	Hamburg	Climate Protection Credit	Supports investments made by Hamburg companies into CO2 abatement and the efficient use of heating, electricity, water and resources. The loans can cover up to 100 per cent of investment costs, as long as costs are between €10 000 and €100 000. Interest rates are subsidised by up to 2.5 per cent.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10028
	Niedersachsen	Energy Efficiency Loans Niedersachsen	Supports the energy-efficient renovation of owner-occupied or rental residential properties by further subsidising Bank for Reconstruction (KfW) loans. Loans cover up to €50 000 per flat, up to a maximum of €10 million per recipient. It is not stated by how much the Bank for Reconstruction (KfW) loan is subsidised.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10644
Other subsidy or grant	National	National Climate Initiative (Die Klimaschutzinitiative)	Hypothecating revenues raised through the auction of a portion of European Union ETS allowances in Germany. Revenues support climate change mitigation and adaptation projects in Germany. Part of the Integrated Energy and Climate program.	Started in 2008, ongoing.	http://www.earthsystemgovernance.org/ac2009/papers/AC2009-0048.pdf and http://www.bmu-klimaschutzinitiative.de/files/BMU_Folder_KI_Allgem_8SeiterENG_431.pdf
	National	International Climate Initiative (Internationale Klimaschutzinitiative)	As for the National Climate Initiative, but revenue is spent on climate change projects in the developing world. A particular focus is on the BRIC countries. In 2008, Germany allocated €120 million raised through EUA auctions to climate change projects in the developing world.	Part of the Meseberg decision of August 2007, currently being implemented. As of September 2010, 184 projects had received a total funding of €360 million through the ICI.	http://www.ecolex.org/ecolex/ledge/view/RecordDetails;document_Chemicals%20-%20Climate%20Protection%20Ordinance..html?DIDPFDSIjsessionid=B28F7540CFC36A68343392E5D25DBE46?id=LEX-FAOC081021&index=documents
	National	Cleaner vehicles in heavy goods sector	A subsidy was announced in 2007 to encourage the shift to the use of cleaner vehicles in the heavy goods sector. The fund was launched with €100 million in 2007, with a further €85 million added in May 2008. Vehicle purchasers were offered the choice of cheaper loans or direct grants of up to €4250 per vehicle. Vehicles were required to meet the European Union's Euro V or EEV Class 1 emission standards. Incentives to buy even cleaner Euro VI vehicles will be available when latest standard is incorporated into German law. This subsidy is part of the scheme to compensate hauliers for the Heavy Goods vehicle tolling system (compansation comprises measures totalling around €600 million a year).	The scheme was promulgated on 13 February 2009 and was in effect from 15 January 2009 (retroactively). The scheme ran until the end of 2009.	http://www.bmvbs.de/SharedDocs/EN/Artikel/UI/incentives-to-purchase-cleaner-heavy-goods-vehicles.html http://www.accaglobal.com/documents/sustain_sei.pdf
	National	Grants for acquisition of low-emission heavy commercial vehicles (related to the 'Cleaner vehicles in the heavy goods sector' program)	KfW (the Bank for Reconstruction) is offering grants of up to €2200 to purchasers of new vehicles above 12 tonnes gross weight which comply with an emissions standard that is higher than that currently in force. The cost of this scheme is €1 billion (€500 million from Federal Government, €500 million from industry).	2008 to 2018	http://www.kfw.de/kfw/en/Domestic_Promotion/Our_offers/Energy_efficiency_ans_environmental_protection_in_enterprises.jsp

Policy type	Jurisdiction	Name	Description	Status and duration	References
	National	Old vehicle scrappage scheme	The old vehicle scrappage system was introduced in Germany in 2009 in order to stimulate demand for new, less polluting vehicles. The scheme offered a €2500 bonus to those who trade in their old vehicles for a new one. The scrapped vehicle had to be at least 9 years old, and registered with the current owner for one year or more. The new vehicle purchased had to meet Euro 4 emissions standards. Used vehicles that were a maximum of one year old could also be purchased under the scheme. The initial budget for this scheme was €1.5 billion. This supported the purchase of approximately 600 000 cars. The budget was increased to €5 billion due to the high demand.	The scheme was promulgated on 13th February 2009 and was in effect from 15th January 2009 (retroactive). The scheme ran until the end of 2009. However, by September 2009 the available budget had been exhausted.	http://www.bmvbs.de/SharedDocs/EN/Artikel/UI/incentives-to-purchase-cleaner-heavy-goods-vehicles.html
	National	program for the promotion of highly-efficient fossil fuel power stations	This program is aimed at smaller providers with a less than 5 per cent market share in electricity generation, and will promote the construction of highly efficient combined heat and power plants and carbon capture and storage-ready power stations. Preference is given to combined heat and power plants. The total budget for this program is €40 million.	The program was outlined in the National Energy Concept of September 2010, but has not yet passed into law.	http://www.bmwi.de/English/Redaktion/Pdf/energy-concept,property=pdf,bereich=bmwi,sprache=en,rwb=true.pdf
	Baden-Württemberg	Support program Coaching	A program to fund coaching and consulting in the areas of innovation, reduction of energy consumption and demographic change. Only Baden-Württemberg-based SMEs are eligible. Funding covers up to 50 per cent of the coaching fees, but no more than €400 per coaching day, or €6000 for one area in total.	Ongoing, set to end 31 December 2013.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=8981
	Baden-Württemberg	Climate Protection Plus - General Part	A program covering non-residential buildings owned by private persons, public institutions, and SMEs in Baden-Württemberg. It consists of three parts: 1) general CO2 reduction program, covering the energy-efficient renovation or construction of non-residential buildings (up to 15 per cent of costs, but no more than €100 000); 2) general consulting program, covering energy-efficiency consulting (50 per cent of consulting fees, but no more than €350 per day and no more than 5 days); 3) general demonstration project part, covering innovative emissions abatement projects (up to 50 per cent of costs, but no more than €200 000).	Commenced in 2002, ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=8423
	Baden-Württemberg	Climate Protection Plus - Municipal Part	Similar to the general part, but focussed on municipalities. Also structured into three parts, covering the same areas, with slightly higher funding: 1) up to 20 per cent, but no more than €200 000; 2) up to 10 consulting days, also up to €100 000 for the creation of regional Energy Agencies, also up to €8000 for participation in the European Energy Award, also up to €50 000 for the re-financing of energy saving investments; 3) also up to 50 per cent, but no more than €400 000.	Part 1ended on 31 October 2010, part 2 on 30 November 2010. Part 3 is ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=11216
	Baden-Württemberg	Climate Protection Plus - Associations Part	Similar to the general part, but focus is on associations and clubs. Associations located in Baden-Württemberg and with an annual turnover of less than €10 million are eligible. Also structured into three parts,with similar coverage. Available funding is slightly lower: 1) up to 40 per cent, but no more than €50 000; 2) up to 5 consulting days, 50 per cent of the fee but no more than €350; 3) also up to 50 per cent, but no more than €50 000.	Parts 1 and 2 are set to end 30 June 2011. Part 3 is ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=11216
	Bavaria	Bavarian Environmental Consulting and Auditing program	This program supports SMEs that want to set up environmental management systems. Maximum support is up to 50 per cent of three days' consulting fees, but no more than €900. If a SME installs an environmental management system, it also covers up to 50 per cent of eligible costs, capped according to the standard of the energy management system.	Ongoing. The current ordinance expires on the 30 June 2014.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=8128
	Bavaria	Support for the Establishment of Energy Agencies	This program supports municipalities in the creation of energy agencies. Only agencies covering more than 250 000 people are eligible (and only if no other municipal energy agency is established in the area). Support can be up to 50 per cent of eligible costs, but no more than €120 000. External coaching and consulting is also supported, up to 50 per cent of fees, with total support capped at €10 000.	Ongoing. The ordinance expires on 31 December 2011.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10913
	Bavaria	Municipal CO2 Abatement	This program supports measures taken by municipalities to reduce CO2 emissions. This includes assessments and preparatory measures. Only projects which are not eligible for any other Bavarian support programs are eligible for this project. External consultancy costs are also not eligible. Grants cover up to 50 per cent of eligible costs, but no more than €30 000.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=7239
	Bavaria	More Efficient Energy Production and Usage (BayREV)	Supports the development and use of technologies leading to more efficient energy production and use. Companies, municipalities, associations, churches and professionals are eligible (as long as they and the project are located in Bavaria). Grants can cover up to 30 per cent of eligible costs, in exceptional cases up to 50 per cent.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=160
	Berlin	Environment relief program (UEP II)	This program supports a variety of projects that reduce the burden on the environment, including research, the removal of environmental damages, reduction of emissions from transport and climate change abatement. The program provides funding to SMEs, public and private research bodies, public bodies and charitable institutions. Climate change abatement projects have to reduce primary energy consumption of fossil fuels by at least 30 per cent. Small enterprises can receive up to 80 per cent of eligible project costs as a grant, medium enterprises up to 70 per cent. Conditions in other cases depend on the financial situation of the claimant.	Ongoing. The ordinance is set to expire 31 December 2011.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=8067
	Brandenburg	Support Directive Environmental Protection	Supports SMEs, municipalities, and municipal enterprises in projects covering waste disposal (in particular measures to secure and re-cultivate closed landfill sites), air pollution control and CO2 abatement. Grants can cover up to 50 per cent of eligible costs, and up to 75 per cent for municipalities and landfill site recultivation.	Ongoing. The ordinance is set to expire 31 December 2013.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10197
	Brandenburg	RENplus	Supports investments to increase renewable energy usage, to increase energy efficiency and other sustainable energy measures. Public and private corporate bodies with locations in Brandenburg are eligible. Grants can cover up to 50 per cent of eligible costs, or up to 40 per cent in South-West Brandenburg (if the project commenced after 31 December 2010). Minimum grant level is €50 000, and the maximum is €3 million.	Ongoing. The ordinance is set to expire 31 December 2013.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=8223

Policy type	Jurisdiction	Name	Description	Status and duration	References
	Bremen	Support of Ecological Efficiency in Firms	Supports measures to improve ecological efficiency in SMEs in Bremen. Consulting concerning the introduction of environment management systems, ecological product design and 'corporate social responsibility' measures is eligible. Grants cover up to 60 per cent of fees for SEs and up to 50 per cent for MEs. The maximum ranges from €2000 to €12 000.	Ongoing. The ordinance is set to expire on 31 December 2012.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10847
	Bremen	program to Support Environmental Technology close to Commercialisation	This program supports Bremen firms in marketing environmental products. Projects have to be managed from Bremen, and evaluation of market introductions has to be done in Bremen. Grants can cover up to 50 per cent of eligible costs, but no more than €50 000.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=7708
	Bremen	Programm to Support Environmental Technology Pilot Projects	This program supports Bremen firms in piloting environmentally friendly products. Only products superceding the state of the art are eligible for piloting support. Pre-commercial research can receive up to 25 per cent of its cost in grants, industrial reserach up to 50 per cent. SMEs can receive additional grants, but in no case can support cover more than 50 per cent of costs. No upper limit for support is stated.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=7710
	Bremen	REN-Ordinance	Supports companies willing to introduce measures to increase the efficiency of energy usage or to use renewable energies. Grants cover up to 40 per cent of eligible costs. Under certain conditions this can be increased to cover 50 per cent of costs.	Ongoing. The ordinance is set to expire 30 June 2012.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=8773
	Hamburg	IMPULS program for Qualifications	This program supports training courses about energy efficient and ecological construction for architects, engineers, builders, property owners, investors and energy consultants. The support is paid to people conducting these training course and consists of a basic grant of €1250, plus €25 per paying attendee. Charges to attendees must not be more than €100.	Ongoing. The program is set to end on 31 December 2013.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10887
	Hamburg	Grants for Modernising Measures of Buildings in Redevelopment Areas	This program supports the renovation of residential buildings in redevelopment areas. Grants can be given as construction support, rent support or lump-sum support. Lump-sum support is €357 per square meter if investment costs are above €510 per square meter. Other forms are determined on a case-by-case basis. The applicant has to supply at least 15 per cent of financing. This program can be combined with Bank for Reconstruction (KfW) funding.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=8382
	Hamburg	Companies for Resource Protection and CO2 Abatement	Grants to support investment that leads to a more efficient use of resources or CO2 abatement. The size of the grant depends on the efficiency improvement or the abatement achieved, and ranges from €1000 to €100 000, but covering a maximum of 30 per cent of project costs.	Ongoing. The ordinance is set to expire 31 December 2013.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=8997
	Mecklenburg-Vorpommern	Climate Protection Support Ordinance	This program provides funding for innovative uses of renewable energies, investment in energy efficiency measures, investment in fuel cells and pre-planning studies of these investments. Municipal corporations, private companies subcontracted by municipal corporations, private companies engaged in the construction of residential properties, associations, charities, and SMEs are eligible. Funding usually covers up to 30 per cent of eligible costs, although a higher percentage can be provided for particularly innovative or effective measures.	Ongoing. The ordinance is set to expire 31 December 2013.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=7194
	Nordrhein-Westphalen	European Energy Award Support	Supports municipalities wishing to certify their operations with the European Energy Award. Funding depends on the size of the municipality. It involves funding for a stock-take, an action plan, follow-up analyses, and possible next-stage funding.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=9661
	Nordrhein-Westphalen	INTERREG IV A - program Germany-Netherlands 2007-2013	INTERREG is a European project intended to foster cross-border cooperation. The INTERREG IV A Germany-Netherlands program supports industrial, technological, innovative, or sustainable regional development cross-border programs in the regions of Nordrhein-Wstphalen, Niedersachsen (Lower Saxony), and a range of Dutch provinces. Funding can be up to 50 per cent of eligible project costs.	Ongoing, set to finish in 2013.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10237
	Nordrhein-Westphalen	Resource efficiency program of NRW	Supports energy efficiency investments, focusing on consulting for SMEs and R&D. Funding covers up to 50 per cent of eligible costs of investments, but not more than €7.5 million; up to 80 per cent of eligible costs of R&D, but no more than €7.5 million; up to 75 per cent for efficiency analyses; and up to 50 per cent for efficiency consulting.	Ongoing. The ordinance will expire on 31 December 2013.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10629
	Nordrhein-Westphalen	Target 2 program NRW	This program is a competition, used to allocate EU funding. Criteria for this competition are: increasing SME competitiveness, reduction of sewage, reduction in air and noise pollution, increases in resource efficiency, and investment in new technology. Funding is a grant, the amount of which is determined according to the same criteria as the Resource Efficiency program of NRW.	Ongoing. The current round of the competition was taking entries until 31 March 2011.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10624
	Rheinland-Pfalz	Support program for Highly Energy Efficient Buildings	The Ministry for the Environment, Forests, and Customer Protection is funding pilot project design solutions for energy-efficient construction and renovation in conjunction with the use of renewable energies. Support can range from €1500 to €50 000 per building.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=9653
Fuel or resource tax	National	Reform of Vehicle Tax on CO2 Basis	Vehicle taxes for passenger cars were reformed to be based on CO2 emissions and engine capacity. Emissions are taxed at €2 per gram CO2/km, with a free allowance of 120 grams CO2/km (to be reduced to 110 by 2012, and 95 by 2014). Owners of diesel cars with emission standard Euro 6 who register the car for the first time between 2011 and 2013 enjoy a one-time tax exemption of €150. New passenger cars that meet Euro 4 standards registered between 5 Nov 2008 and 30 June 2009 were granted a one year tax free grace period. Vehicles fulfilling Euro 5/6 standards were granted a tax free grace period of up to 2 years. The tax free grace period ended on 31 December 2010 at the latest. Cars first registered until 4 November 2008 will be taxed as before until December 31st 2012, and then included in the system of the new vehicle tax scheme. Light goods vehicles up to 7.5 tonnes loading capacity also taxed on the basis of their weight. Heavy goods vehicles over 7.5 tonnes are charged on basis of their emission standards and their loading capacity. Electric vehicles are exempt from the tax for a period of five years. Subsequently they will pay a tax according to their w	The reform was passed in March 2009, and entered into force on 1 July 2009. It will initially only apply to cars registered after 1 July 2009. Starting in 2013 the tax will be applied to all cars, after a transition period (the details of which are still to be fixed).	http://www.bundesregierung.de/Content/DE/Artikel/2009/01/2009-01-13-konjunkturpaket-neuregelung-kfz-steuer.html and http://www.bundesfinanzministerium.de/nn_4158/DE/BMF__Startseite/Service/Downloads/Abt__I/1101201a6004,templateId=raw,property=publicationFile.pdf http://www.acea.be/images/uploads/files/20100420_EV_tax_overview.pdf

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	National	Fuel excise	Germany levies fuel excise on most transport fuels, with a tax of €0.65/L of petrol and €0.47/L of diesel (tax rates are higher for fuels with sulphur content over 10 miligrams per kilogram).	Ongoing.	http://www.zoll.de/b0_zoll_und_steuern/b0_verbrauchsteuern/b0_energie/a0_grundsatz_besteuerung/b0_hoehe_energiesteuer/index.html and http://www.umweltdaten.de/publikationen/fpdf-l/3896.pdf
	National	Reinforcing the Influence of the HGV Toll	The system of tolls on heavy goods vehicles has been revised to allow for differential charges based on greenhouse gas emissions, and reductions in tolls for retrofitting certain types of filters.	In June 2008, the Federal Cabinet approved an amendment of the Toll Rate Ordinance. The amendment entered into force on 1 January 2009.	http://www.umweltdaten.de/publikationen/fpdf-l/3517.pdf
Other tax	National	Electricity Tax (Stromsteuer)	A consumption tax levied on the use of electricity. Reductions include a rebate of €5.13 per MWh for manufacturers, agriculture and forestry, and a maximum tax bill of €1000 per year until 31 December 2012, subject to Germany meeting its emissions abatement targets. Electricity used by trains and buses is taxed at €11.42 per MWh. Tax exemptions include electricity used in the process of producing electricity, electricity from plants of less than 2MW capacity if it is used locally, electricity from emergency generators, and electricity produced and consumed in ships and aircraft. Electricity used for electrolysis, the production of glass, ceramics, cement, clinker, concrete, and metal, or for chemical reduction processes is also tax exempt. Electricity from renewable energy sources (defined as wind, solar, geothermal, landfill gas, sewage gas, biomass, and hydro with less than 10 MW capacity) is only exempt if it is taken from a grid or transmission line transmitting nothing but renewable energy source electricity (renewable energy source electricity fed into the normal grid is taxed at the full rate). In 2009, tax revenue from the electricity tax was €6278 million.	Ongoing.	Destatis (German Statistical Agency), accessed at http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/SharedContent/Oeffentlich/B3/Publikation/Jahrbuch/FinanzenSteuern,property=file.pdf Also text of the law, accessed at http://www.gesetze-im-internet.de/stromstg/BJNR037810999.html
Regulatory instruments					
Renewable energy target	National	Regulation on Feed-in of Biogas into Natural Gas Networks	The ordinance specifies the duty to connect biogas plants to the natural gas network, and summarises and expands the existing prioritisation rules for biogas feed-in.	An Ordinance on Amendment of the Gas Network Access Ordinance (Gasnetzzugangsverordnung), the Ordinance on Gas Network Tariffs (Gasnetzentgeltverordnung), the Ordinance on Incentive Regulation (Anreizregulierungsverordnung) and the Ordinance on Electricity Grid-use Fees (Stromnetzentgeltverordnung) entered into force on 12 April 2008.	
Electricity supply or pricing regulation	National	Smart Metering	Opening up competition in the market for the operation, reading and data processing of electricity meters. These functions had historicaly been carried out by electricity network operators. The Act seeks to provide benefits to consumers and to encourage technological innovation in electricity metering. It also makes the installation of smart meters mandatory on any buildings being connected to the grid after 1 January 2010, or undergoing major renovations.	Ongoing.	See BGBL Nr. 40, issued on the 08.09.2008, page 1790 at http://www.bgbl.de/Xaver/start.xav?startbk=Bundesanzeiger_BGBl
Technology standard	National	Clean Power Station Technologies	Standards on the emission of oxides of nitrogen from new power stations (as of 2012).	The 37th Ordinance on the Execution of the Federal Emmission Control Act (BImSchV), which would establish new upper limits on nitrous oxide emissions of new power stations (as of 2012) was not introduced, but its provisions were 'divided' among the 13th BimSchV (Ordinance covering large combustion plants, including power stations) and the 17th BimSchV (Ordinance covering the combustion of garbage). The necessary changes to the two ordinances were passed on 30 January 2009.	http://www.bgbl.de/Xaver/start.xav?startbk=Bundesanzeiger_BGBl
	European Union regulation	CO2 Strategy for Passenger Cars	European Union regulations limiting the CO2 emissions of new passenger cars. The objective of the regulation is to limit the average emissions of the new car fleet to 120 grams CO2 per kilometre by 2012. However, the requirement is being phased in until 2015 by allowing producers to take less than 100 per cent of their newly produced cars into account (thereby allowing a skewing towards the less emissions intensive cars). Under the regulations larger cars will be permitted to have higher emissions and manufacturers will be permitted to average their new vehicle emissions across models. The target of 120 grams CO2 per kilometre will be achieved through two mechanisms. 130 grams per kilometre is to be met by improvements to vehicle design, and 10 grams per kilometre by other measures (such as gear-change indicators, tyre pressure checks, low-resistance tyres and biofuels). A further "long-term target" of 95g/km by 2020 is included in the regulation.	Relevant binding regulation has been issued by the EU (REGULATION (EC) No 443/2009 of the European Parliament and of the Council on 23 April 2009). Requirements are to be phased in: in 2012, 65 per cent of each manufacturer's newly registered cars must comply on average with the limit value curve set by the legislation. This will rise to 75 per cent in 2013, 80 per cent in 2014, and 100 per cent from 2015 onwards.	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32009R0443:EN:NOT
	National / European Union	Vehicle Emissions Standards (vans)	Proposed EC Regulation sets an EU-wide target for new van CO2 emissions of 175g CO2/km by 2016 and 135gCO2/km in 2020. In December 2010, the European Parliament and the Council agreed to delay full introduction of the short-term target of 175 g/km to 2017, which is one year later than proposed by the Commission. The EU co-legislators also agreed to adjust the ambition of the 2020 target by increasing it from 135 g/km to 147 g/km.	The European Parliament voted on 15 February 2011 to formally approve an agreement on draft legislation that was reached by the Parliament, the European Council and the European Commission in December 2010.	http://www.bmu.de/english/current_press_releases/pm/46853.php

Policy type	Jurisdiction	Name	Description	Status and duration	References
	National / European Union	Tyre pressure monitoring systems, gear shift indicators and low rolling resistance tyres	EC Regulation No. 661/2009 requires, amongst other things, the introduction of tyre pressure monitoring systems, gear shift indicators and the use of low rolling resistance tyres.	Ongoing. Phased introduction from 2012 onwards.	
	National / European Union	Vehicle Air Conditioning System Regulations	Directive 2006/40/EC controls the use of fluorinated greenhouse gases in air conditioning systems in motor vehicles. The directive bans air conditioning systems that use greenhouse gases with a global warming potential greater than 150, unless the rate of leakage is within permissible limits.	This legislation came into force under type-approval of all new vehicle types (i.e. new models) from 21 June 2008 and applied to all sales of new vehicles from 21 June 2009. Total ban on air conditioning systems that use greenhouse gases with a global warming potential greater than 150 will come into effect for type-approval of all new vehicles types from 1 January 2011, and the sale of all new vehicles from 1 January 2017.	http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_161/l_16120060614en00120018.pdf; http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_161/l_16120060614en00120018.pdf
Fuel content mandate	National	Biofuels Quota Act	A minimum amount of biofuel must be consumed as transport fuel each year, either neat or blended with petrol or diesel. Each year, the proportion of biofuel in conventional fuel (petrol or diesel) is set (in terms of energy content). In 2009 quotas were 4.4 per cent for biodiesel (blended with diesel), 2.8 per cent for ethanol (blended with petrol) and 5.25 per cent for all biofuels.	An Act for amendment of support for biofuels ('Gesetz zur Änderung der Förderung von Biokraftstoffen') entered into force on 15 July 2009.	http://www.umweltdaten.de/publikationen/fpdf-l/3517.pdf
Energy efficiency regulation	National	Energy Saving Ordinance	Key elements of the ordinance include a tightening of energy-efficiency requirements for new buildings and for cases involving major changes in existing buildings by an average of 30 per cent. For 2012, a tightening by a further 30 per cent is planned. The ordinance also includes an expansion of individual requirements pertaining to retrofits; gradual phasing-out – supported by financial incentives – of night-current-storage heating systems; measures for strengthening implementation of the Energy Saving Ordinance; and incentives for intensified use of renewable energies.	An ordinance for amendment of the Energy Saving Ordinance (Energieeinsparverordnung) was approved by the Federal Government on 18 March 2009, in a form that includes changes imposed by the Bundesrat. The ordinance for amendment to the Energy Savings Ordinance was formally promulgated in the Federal Law Gazette on 29 April 2009 and entered into force on 1 October 2009.	http://www.bgbl.de/Xaver/start.xav?startbk=Bundesanzeiger_BGBl and http://www.umweltdaten.de/publikationen/fpdf-l/3517.pdf
	National	Operating Costs of Rental Accomodation	The amendment to the heating costs ordinance will change the ratio of consumption to non-consumption related charges for energy use in multiple-occupancy buildings. The ratio was 50:50. Changes will provide greater incentives for reducing energy use. There are other administrative changes to how energy bills are charged to tenants.	On 5 November 2008, the Federal Cabinet approved an amendment of the Ordinance on Heating Costs (Heizkostenverordnung). The amendment entered into force on 1 January 2009.	
	National	Modernisation Program to Reduce CO2 Emissions from Buildings	Grants and loans to increase the energy efficiency of new and existing residential buildings. The program is administered by the KfW (the Bank for Reconstruction). From 2006 to 2010, the government spent a total of €7.1 billion on this program and the energy-efficient modernisation of social infrastructure.	Approved until 2011. There is no official indication whether the program will be concluded in 2011 or continued into 2012 and beyond.	http://www.bmvbs.de/SharedDocs/DE/Artikel/SW/co2-gebaeudesanierung-energieeffizient-bauen-und-sanieren-die-fakten.html and IEKP 2007 and http://www.umweltdaten.de/publikationen/fpdf-l/3517.pdf
	National	Energy Efficient Modernisation of Social Infrastructure	Low-interest loans and grants to make energy-efficiency improvements to schools, day-care facilities and school gyms.	Concluded in 2010.	http://www.bmvbs.de/SharedDocs/DE/Artikel/SW/co2-gebaeudesanierung-energieeffizient-bauen-und-sanieren-die-fakten.html and http://www.bmvbs.de/SharedDocs/DE/Artikel/SW/zweites-konjunkturpaket-massnahmen-im-bereich-bau-und-stadtentwicklung.html?nn=36238
	National	Renewable Energies Heat Act	Developers of new buildings will be obliged to use a percentage of renewable energy to heat new buildings. Under the act, a certain percentage of expected heating energy must be sourced from renewable energies. The precise percentage varies from technology to technology. The mandate can alternatively be fulfilled by implementing stringent energy saving measures. This act is explicitly interlinked with the market incentive program (MAP - a capital grants program to support the installation of renewable energies heating technologies)	Ongoing.	
	National	program for the Energy Efficient Modernisation of Federal Buildings	Building upgrades for government buildings.	From 2006 to 2009, €120 million per year was provided for energy-oriented modernisation of civil and military federal buildings. The IECP provides for the program to be continued beyond 2009 – until 2011 – at its existing level €120 million per year). There is no indication whether the scheme will continue past 2011.	http://www.bundesregierung.de/Content/DE/StatischeSeiten/Breg/EnergieUndKlima/bundesgebaeude-sanierungsprogramm.html and http://www.umweltdaten.de/publikationen/fpdf-l/3517.pdf
	Bavaria	Municipal Energy Savings Concepts	This program supports analyses of how to save energy in municipal buildings and operations. Grants cover up to 50 per cent of eligible costs, with a cap of €25 000 per analysis.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=7238

Policy type	Jurisdiction	Name	Description	Status and duration	References
	Brandenburg	Energy Savings through Modernising Owner-Occupied Residential Property	Supports the modernisation and renovation of owner-occupied residential property located in cities in Brandenburg (only property built before the 2 October 1990 is eligible). Renovations must bring a property up to the energy-usage standards mandated by the Federal Energy Saving Ordinance. Only owners earning less than €70 000 per year are eligible. Grants are as follows: a basic support of €18 000, another €5000 for low-income households, up to another €5000 for particularly efficient heat-insulation, and up to €5000 for listed buildings.	Ongoing. The ordinance is set to expire 31 December 2011.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10941
	Bremen	Insulation in Residential Properties	This program supports improvements to insulation in private residential property in Bremen. Buildings must have been constructed prior to 1 January 1984, and contain a maximum of 10 flats. Only projects costing more than €2500 are eligible, the amount granted depends on the particular improvement. No maximum amount is stated.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=7455
	Hamburg	Measures for Modernisation and Energy Efficiency in Rental Residential Properties	This program supports energy saving and other modernisation measures in residential rental properties constructed before 31 December 1984, that are deemed to be worthy of preserving. The grant may cover up to 40 per cent of eligible costs, but no more than €280 per square meter. This program can be combined with Bank for Reconstruction (KfW) funding.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=9118
	Hamburg	Energy Saving Measures in Rental Residential Properties	This program supports energy-saving renovation of rental properties. The level of support is €0.20-0.30 per kWh of heating energy saved annually, depending on the energy savings achieved. This program can be combined with Bank for Reconstruction (KfW) funding.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=9117
	Hamburg	Climate Protection program - Hamburger Energiepass	This program supports energy consulting for the improvement of existing buildings. Funding is given for a 'Beratungs-Check' (advice check), analysing energy savings potentials, and the 'Hamburger Energiepass' - an analysis of savings potentials conducted by engineers, and coupled with renovation reccomendations. The grant covers 40 per cent of costs.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10143
	Hessen	Support of energy efficient renovation of residential buildings and selected non-residential buildings	This program supports renovation measures that serve to reduce the annual heating requirement to a maximum of 25kWh per square meter. The building must be in Hessen. Support covers up to 50 per cent of eligible costs.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10199
	Mecklenburg-Vorpommern	Energy Efficient Renovation of the Social Infrastructure of Municipalities in Mecklenburg-Vorpommern. (Investitionspaktrichtlinie)	This program supports investments intended to reduce the primary energy use of municipal infrastructure. Funding covers up to two-thirds of eligible costs, or up to 85 per cent for municipalities in financial need.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10231
	Niedersachsen	Optimisation of Energy Management	This program supports investments in the energy-efficient renovation and modernisation of public buildings. Only municipalities are eligible. For municipalities in the region 'Competitiveness and Employment' maximum funding is 50 per cent of eligible costs, for municipalities in the region 'Convergence' 75 per cent. Grants are at least €200 000.	Ongoing. The ordinance is set to expire 31 December 2013.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10569
	Nordrhein-Westphalen	Investment Package for the Energy Efficient Renovation of Social Infrastructure	Finance for the renovation of social infrastructure (such as schools, school gyms, town halls). Buildings have to lie in redevelopment zones, or in municipalities that are under budgetary stress. Funding can cover up to two-thirds of eligible project costs.	Ongoing. The ordinance is set to expire 30 June 2013.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10203&typ=KU
Synthetic greenhouse gas regulation	National (complementing European Union regulation)	Reduction of Emissions of Fluorinated Greenhouse Gases	Regulation that caps emissions of fluorinated gases from refrigeration, air conditioning and heat pump equipment that contains such gases. The German government ordinance complements European Union Regulation no. 842/2006.	Ongoing.	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32006R0842:en:NOT
Urban or transport planning regulation	National	Reducing Land Use	This amendment to the building code requires economical use of land, reduces the subsidy available for newly-built houses, and reduces the mileage allowance rate to reduce incentives for migrating from the countryside to the city.	Published 2004. Ongoing.	http://www.bmvbs.de/cae/servlet/contentblob/29476/publicationFile/3588/reducing-land-use.pdf
Other regulation	National	Chemicals Climate Protection Ordinance	Provisions that apply to mobile and stationary cooling installations covering leakproofness and labelling of the installations and on recovery and return of the refrigerants used. The objective is to reduce emissions of fluorinated GHGs.	Ongoing.	http://ec.europa.eu/environment/sme/pdf/environmental_agreement_en.pdf
	National / European Union	Nitrates Directive Council Directive 91/676 of 12 December 1991	The EU Nitrates Directive limits the use of fertilisers on land located in 'nitrate vulnerable zones' in order to improve water quality (avoiding run-off of fertilisers into water supplies). This reduces N2O emissions.	Directive adopted in 1991, ongoing.	http://ec.europa.eu/environment/pubs/pdf/factsheets/nitrates.pdf
	National	Waste Water Ordinance (AbwV)	Implements the Industrial Pollution Prevention and Control (IPPC) Directive which aims to minimise pollution from large industrial installations. Affects large scale pig and poultry farms as well as other industry. Measures must be taken by livestock farms to reduce ammonia emissions (mostly covering the storage of animal manure). Ammonia is not a greenhouse gas but the measures affecting manure treatment also influence methane and N2O emissions.	Introduced June 2004, ongoing.	http://www.bmu.de/english/water_management/downloads/doc/3381.php
	National	Emission Reduction from Adipic Acid and Nitric Acid Production	Reduction of N2O emissions from industrial processes. 'TA Luft' (Technical Instructions on Air Quality Control) defines an emission threshold of 800 mg N2O/m3 from 2010, and inclusion of adipic and nitric acid production in the European Union Emisisons Trading Scheme from 2013.	Ongoing.	
	National / European Union	Ecodesign Directive (2009/125/EC)	The Ecodesign Directive aims to reduce the environmental impact of products by the systematic integration of environmental standards, such as energy consumption or emissions reduction, in the product design. It applies to all energy using products, except vehicles for transport. The first directive came into force in 2005 and the second in 2009. The EU member states have to transpose the directives into national law. In Germany, the so called 'Energiebetriebene-Produkte-Gesetz' came into force in 2008 (transposing the directive from 2005).	The new Ecodesign came into force quite recently. The amendment of the 'Energie-Betriebene Produkte-Gesetz' is due to follow soon.	http://ec.europa.eu/clima/studies/effort/docs/impact_ggas_en.pdf

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	National	Reduction of Greenhouse Gas Emissions (CH4 and N2O) in the Waste Sector	Legal requirements regulating the management of waste, covering issues including design, operation and post-operation procedures for landfills as well as the minimum standards regarding the waste to be dumped. The relevant ordinance is the 'Ordinance on Landfill Sites and Long-Term Storage Facilities'. The standards requre pre-treatment of organic waste. Currently, there are 70 waste incineration plants and 48 mechanical-biological treatment plants that carry out pre-treatment, and from from 2015 there will be legal obligations to install seperate collection systems for biowaste.	Ongoing.	http://www.senternovem.nl/mmfiles/Germany.doc_tcm24-241031.pdf
Direct government expenditure					
Government procurement - general	National	Procurement of Energy-Efficient Products and Services	Encourages government agencies to consider energy efficiency in procurement decisions. Guidelines apply to all of the Federal Government's agencies that award public contracts. Germany's states (Länder) and municipalities are reviewing the possibility of adopting this regulation.	Ongoing	
	National	National Platform for Electromobility	Funding the development and comercialisation of electric mobility. This includes the 'Electric mobility in pilot regions' project (below), the establishment of a battery testing centre (with crash tests) and providing funds for the establishment of hydrogen filling stations.	Ongoing.	http://www.bmvbs.de/SharedDocs/EN/Artikel/IR/electric-mobility-pilot-regions.html
Support for research and development					
R&D - general and demonstration	National	Carbon Capture and Storage Technologies	The German Government is develpoing a legal framework for carbon capture and storage (CCS), and increasing its support for R&D. The government is aiming to set up at least two CO2 storage facilities, and build demonstration carbon capture and storage plants.	Ongoing. A CCS law is currently being drafted.	http://www.bmwi.de/BMWi/Redaktion/PDF/E/energiekonzept-10-punkte-sofortprogramm,property=pdf,bereich=bmwi,sprache=de,rwb=true.pdf
	National	Electric Mobility	Government support for research into electric vehicle technologies. The National Development Plan for Electric Mobility aims to have 1 million electric cars on the road in Germany by 2020. Currently eight pilot projects are underway (Hamburg, Bremen/Oldenburg, Rhine-Rhur, Rhine-Main, Saxony, Stuttgart, Munich and Berlin-Potsdam), involving people from academia, industry and local authorities. €500 million from the second economic stimulus package has been earmarked for electric vehicle R&D projects. Total funding for electric mobility pilot projects is €130m.	Ongoing. A National Development Plan for Electric Mobility was published in August 2009. Expected to run until 2011.	http://www.bmwi.de/Dateien/BMWi/PDF/nationaler-entwicklungsplan-elektromobilitaet-der-bundesregierung,property=pdf,bereich=bmwi,sprache=de,rwb=true.pdf http://www.bmvbs.de/SharedDocs/EN/Artikel/IR/electric-mobility-pilot-regions.html
	National	National Hydrogen and Fuel Cell Technology Innovation program (NIP)	Establishment of the National Organisation for Hydrogen and Fuel Cell Technology (NOW) in February 2008 to be the driving force in the development and commercialisation of internationally-competitive hydrogen and fuel cell technology products and to assume responsibility for the National Innovation Program.	Commenced in 2008. Ongoing.	
	National	Federal Government Fuel Strategy	The purpose of the fuel strategy is to concentrate resources on alternative fuels and powertrains and to accelerate their development. The strategy includes tax relief on various alternative fuels until 2020. The strategy also includes the Clean Energy Partnership - 13 industry consortium partners working together primarily on hydrogen powered mobility.	Ongoing (currently being updated).	http://www.bmvbs.de/cae/servlet/contentblob/29492/publicationFile/289/the-fuel-strategy-alternative-fuels-and-innovative-drive-systems.pdf
	Baden-Württemberg	Environmental Technologies	In collaboration with the European Fund for Regional Development, Baden-Württemberg is supporting the development of innovative environmental technologies. SMES, universities and research institutes with locations in Baden-Württemberg are eligible. Projects must be limited to 18 months. The grant covers up to 100 per cent of project costs for research bodies, and up to 80 per cent of project costs for SMEs, in both cases no more than €500 000.	The project will run from 2007 to 2013.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10152
	Bavaria	Support program 'Electromobility'	The program covers R&D into electric transport conducted in Bavaria. A variety of R&D areas are eligible, including electric powertrains, battery technology, software-based energy management systems, safety technology, and relevant infrastructure. Companies, universities and research institutes are eligible. The grant can cover up to 50 per cent of eligible costs for industrial research, up to 25 per cent for experimental R&D, up to all expenses for universities, and up to all eligible costs for research institutes.	Ongoing. The current ordinance expires on 30 June 2014.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=10708
	Bremen	Creation of a Recycling Infrastructure Industry	Supports R&D projects looking into new environmentally-friendly products, or innovative waste recovery or avoidance technologies. Research institutes (public and private) and companies with locations in Bremen are eligible. Support covers up to 25 per cent of eligible costs for demonstration projects and up to 50 per cent for industrial basic research. SMEs are eligible for up to 20 per cent bonus grants and certain projects are eligible for another 15 per cent bonus grants. Total grants must not exceed 50 per cent of costs for demonstration projects, or 75 per cent for industrial basic research.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=7305
	Bremen	Support for Projects in Applied Environmental Research	This program supports scientists with permanent contracts at research institutes in Bremen. Only projects receiving no private-sector funding are eligible, and project length should not exceed 2 years. The grant can cover up to 100 per cent of eligible expenses, but no more than €150 000.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=7711
	Bremen	program to Support Environmental Technology in Combined Projects	This program supports joint projects conducted by private companies in association with research institutes. Only research into environmental technology is eligible. Pre-commercial research can receive up to 25 per cent of its cost in grants, industrial research up to 50 per cent. SMEs can receive additional grants, but grants must not cover more than 50 per cent of the private company's cost share. Research institutes are eligible for up to 80 per cent of their cost. The grants must not cover more than 75 per cent of total combined project costs.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=7709
	Hessen	Climate E3	This program supports R&D concerning the reduction and avoidance of GHG emissions. Grants cover up to 50 per cent of eligible costs for companies, and up to 100 per cent of costs for universities, research institutes and comparable institutions, but no more than €200 000.	Ongoing.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=11206
	Hessen	Ordinance to the Hessian Energy Law	This program supports the research and deployment of energy-efficiency technology and renewable-energy technology. Funding depends on the particular project, and can range from 25 per cent to 60 per cent of eligible project costs.	Ongoing. The ordinance is set to expire 31 December 2013.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=7208

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	Niedersachsen	Innovation Support program Niedersachsen	This program is aimed at SMEs and other enterprises engaged in the development and research of energy efficient products. Funding covers up to 35 per cent of eligible costs for SMEs and up to 25 per cent for other firms. Small firms younger than 10 years are eligible for up to 45 per cent.	Ongoing. The ordinance is set to expire 31 December 2015.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=8970
	Rheinland-Pfalz	Demonstration project for the extraction of energy from biomass	Rheinland-Pfalz, together with the European Regional Development Fund, is supporting demonstration plants and processes for environmentally sound and sustainable uses of renewable resources. Funding usually covers up to 45 per cent of additional costs (costs for a renewable plant minus costs of a fossil-fuel plant of the same capacity).	Ongoing. The ordinance will expire on 31December 2013.	http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/suche.html?get=7af6508441e8acf239fb01b4d7aeb4d8;views;document&doc=11075
Other					
Information provision or benchmarking	National	Support Programs for Climate Protection and Energy Efficiency (apart from buildings)	Funds from the sale of EU ETS emissions allowances will be used to provide subsidies for energy efficiency consulting to households and businesses. There are also subsidies available for other energy efficiency measures.	Ongoing.	http://www.umweltdaten.de/publikationen/fpdf-l/3517.pdf
Labelling scheme	National	Energy Efficient Products	Scheme for energy efficiency design standards for applicances and energy consumption labels. Following a transition period, all devices introduced to the market must meet certain minimum energy-efficiency standards. 11 product classes have since been regulated, including electric motors, dishwashers, washing mashines and TVs. A working plan for 2009-2011 sets out which product classes are to be regulated next. There may be a move to include a 'top-runner' approach into the Ecodesign directive. The EU Labelling Directive was revised in May 2010, extending the scope from only household appliances to other products. So far, four delegated acts have been set into force, providing a label for dishwashers, washing machines, refrigerators (an update of the existing label) and televisions.	The Ecodesign Directive (Directive 2009/125/EG) was passed on 21 October 2009, providing a framework for introducting minimum standards. The EU Labelling Directive was revised in May 2010.	http://www.umweltdaten.de/publikationen/fpdf-l/3517.pdf and http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0660:FIN:en:PDF
	National	Energy Labelling of Passenger Cars	New passenger vehicles will be labelled to indicate their energy efficiency (emissions of CO2 per km, adjusted to account for the weight of the car, as well as fuel consumption/mileage and expected vehicle tax). A colour-coded scale will be displayed on cars in sales rooms to make this information easily accessible.	The Ordinance on Energy-Consumption Labelling of Automobiles (Pkw-Energieverbrauchskennzeichnungsverordnung) is currently being revised, with the aim of including information on CO2 emissions and on fuel consumption in the form of an efficiency scale. A draft version of the new ordinance was submitted to the Federal States and other stakeholders on 12 August 2010, and the European Commission was notified on 13 October 2010. Due to comments from three EU Member States, the notification procedure has been extended to 14 April 2011. It is planned that the Ordinance will go before the Bundestag (lower house) in May/June 2011, and before the Bundesrat (federal or upper house) in June/July 2011. The Ordinance would then come into force in October 2011.	http://www.bmwi.de/BMWi/Navigation/Energie/Energieeffizienz-und-Energieeinsparung/energieeinsparung,did=354752.html
	National / European Union	Labelling Directive (2010/30/EU)	The Labelling Directive aims to provide more information for consumers about the energy efficiency of products. The starting point was the directive 79/530/EEC, followed by the 92/75/EEC, which introduced the labelling of products' energy efficiency performances from 'A' to 'G'. The German transposition of the EU directive is the 'Energieverbrauchskennzeichnungsgesetz'. Regarding ongoing energy efficiency improvements, an amendment of the regulatory framework was needed. This is why the Commission developed a new proposal, introducing the new energy efficiency levels of 'A +' to 'A +++' and expanding the application of the labelling from domestic appliances to all energy-related products (except transport sector).	The Directive came into force the 28 September 2010. There is no transposition into German national law so far.	http://www.bmwi.de/BMWi/Redaktion/PDF/Publikationen/br-evaluierung-zur-umsetzung,property=pdf,bereich=bmwi,sprache=de,rwb=true.pdf
	National / European Union	Tyre Labelling Regulation	Regulation 1222/2009. The fuel efficiency, wet grip and external rolling noise performance of tyres will be rated on a scale of A-G. This Regulation is an extension of the consumer labelling directive.	Regulation applies from 1st November 2012	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:342:0046:0058:EN:PDF
Advertising or educational scheme	National	Neues Fahren ('New Driving' meaning Eco-driving)	An advertising and educational campaign to encourage smarter, safer, smoother driving. Includes training for bus and HGV drivers.	Since 2000, ongoing.	http://www.neues-fahren.de/neues-fahren/default.htm
	National	Efficient Mobility' (Effizient Mobil) and 'Me and My Car' (Ich und mein auto) programs.	Provision of information and advice on alternatives to the car. The aim is to inform local government and enterprises on mobility management and best practice, and to encourage road users to change their behaviour. The 'Me and My Car' campaign aims to inform motorists of the most efficient ways to use their cars.	Ongoing.	http://www.effizient-mobil.de/
	National	Energy Saving Advisory programs	Programs to promote energy efficiency. The program 'Energy saving advice on the spot' advises owners of houses and apartments. To promote independent consulting for private consumers on energy saving possibilities, government supports projects of the Deutsche Energie-Agentur GmbH (dena) and the Federation of Consumer Organizations and consumer groups - Consumer Federation of e. V. (vzbv) with federal grants.	Ongoing.	http://www.bafa.de/bafa/de/energie/index.html
	National	Efficient Use of Electricity	Information campaign aimed at three areas: private households; services sector; and industry and commerce. Provides information and advice.	Ongoing.	http://www.dena.de/themen/thema-strom/

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	National	Energy Efficient Buildings	Campaign aimed at reducing building energy consumption. It contains eleven current projects, including a building energy performance certificate scheme and an initiative to introduce small fuel cells for environmentally-friendly electricity and heat generation. It also includes refurbishment of old buildings and schools.	Ongoing.	http://www.dena.de/themen/thema-bau/
Broad target or intergovernmental framework	National	10 Point Immediate Action program	A 10 point action plan: 1. Amendment to the Offshore Installations Ordinance (SeeAnlV) to prevent hoarding of licences and to ensure progress of installations. 2. Special program “Offshore Wind Power” with a total credit volume of €5 billion. 3. Government dialogue with stakeholders to ensure efficient electricity grids. 4. Facilitate the collective connection of wind farms in the North and Baltic Seas to the grid. 5. Exemption of new pumped-storage plants from grid charges to create incentives for new storage capacity. 6. Information campaign 'Grids for environmentally sound energy supply'.	The goal is to put this program into practice by 31 December 2011, with subsequent reporting every 3 years starting in 2013.	http://www.erneuerbare-energien.de/inhalt/46517/3860/
			7. Nationwide grid expansion planning. 8. Heat contracting in tenant protection legislation - German Government will present a draft Act to establish a uniform framework for heat contracting. 9. The German Government will adopt a draft Act on carbon capture and storage in the near future to create a legal basis for testing the safe storage of carbon dioxide. 10. The German Government will present a draft Act on the establishment of a market transparency agency for wholesale trade in electricity and gas to uncover potential flaws in price formation more effectively.		
	Bavaria	Bavarian Climate program 2020	This program consists of a set of measures across buildings, transport, renewable energy, industry and other areas. Measures were reconciled with national measures, and complement the ongoing measures of the Bavarian Climate Protection Concept. Total budget for the period 2008-2011 is €750 million.	Climate Protection Strategy was adopted October 2000. Climate Protection program 2020, published in 2007, contains an action plan for 2008-2011 after which a decision will be taken regarding further measures.	http://www.stmug.bayern.de/umwelt/klimaschutz/klimaprogramm/doc/klimaprogramm2020_en.pdf http://www.theclimategroup.org/programs/policy/states-and-regions/bavaria/
	National / European Union	Energy End-Use Efficiency and Energy Services Directive [2006/32/EC]	The Directive indicates that member states must achieve an energy saving target of 9 per cent between 2008 and 2016 (compared to the average end-energy consumption between 2001 and 2005) and publish three national action plans on energy efficiency. Germany published a National Action Plan on energy efficiency in November 2007.	The next national action plan on energy efficiency has to be published in 2011.	http://www.bmwi.de/BMWi/Redaktion/PDF/Publikationen/nationaler-enerieeffizienzplan,property=pdf,bereich=bmwi,sprache=de,rwb=true.pdf
Voluntary agreement	Bavaria	Bavarian Environmental Agreement (or ‘Environmental Pact')	An agreement of environmental objectives between the Bavarian government, industry and SMEs. In return for reducing emissions, the government offers subsidies or relief from certain administrative costs. An evaluation process is in place to verify emission reductions. 10 other Länder (federal states) have ‘environmental partnerships' similar to the Bavarian agreement. The cost of this scheme is €185 million.	Ongoing.	

India

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Subsidies and taxes					
Capital subsidy	National	Small Hydro Power Subsidy Program	Subsidies for private sector organisations to set up new projects (up to 25 MW capacity). Project developers are required to provide a minimum of 50 per cent of funding. Amount of subsidy is dependent on location (for example, for special states, subsidy is Rs.2 crore for 1st MW (A$455 000 and Rs.30 lakh for each additional MW (A$68 000)). The budget for this program is Rs.700 crore (approximately A$158 million) over the five years of the 11th Plan.	Funding provided for full five years of the 11th Plan.	http://www.mnre.gov.in/adm-approvals/shp_scheme.pdf http://planningcommission.nic.in/aboutus/committee/wrkgrp11/wg11_renewable.doc
	National	Small Wind Energy and Hybrid Systems Subsidy Program	Provides subsidies for setting up water pumping windmills and aero generators/wind-solar hybrid systems and also provides finance for field trials and demonstration projects. Range of eligible organisations include corporations, individuals, NGOs, Central/State Government agencies, local bodies and research organisations. The budget for this program is Rs.5.0 crore (A$1.1 million) for 2010-2012.	The scheme was modified in 2010 and has funding through to the end of 2012.	http://www.mnre.gov.in/adm-approvals/wind-hybrid-system.pdf
	National	Biogas based Power Generation Subsidy Program	Subsidies for setting up biogas power generation. Eligible parties include village level organisations, NGOs and private entrepreneurs in rural areas. Amount of subsidy depends on generation type, capacity and location (special category states receive higher capital subsidy). The budget for 2009-10 is Rs.5.0 crore (approx A$1.1 million).	Approval for funding in 2009-10.	http://www.mnre.gov.in/adm-approvals/biogaspower.pdf http://mnre.gov.in/prog-biomasspower.htm
	National	Grid Interactive Biomass Power and Bagasse Cogeneration Project Subsidy Program	The scheme provides a subsidy to projects that set up biomass combustion-based power projects and bagasse cogeneration projects in private/cooperative/public sector sugar mills. MNRE will also provide financial support for (among other things) R&D activities, organisation of seminars/symposiums/workshops/training program, strengthening of technical institutions, testing facilities, engaging consultants, and undertaking studies on a case by case basis.	This scheme modifies earlier schemes relating to grid interactive renewable power generation projects based on biomass combustion and bagasse cogeneration and will be applicable from 1 April 2010 and will continue up to the end of the 11th Plan period (31 March 2012).	http://mnre.gov.in/adm-approvals/grid-ipgp.pdf
	National	Demonstration Program on providing incentives to banks/micro finance on installations of solar home systems through loans in the country	Provides banks/micro financing institutions with incentives to extend loans to consumers and provide information about loans to purchase solar home lighting and other small solar systems in villages/areas where the power supply is unreliable. The budget for this program is up to Rs.244 crore (approx A$50 million) for year 2010-11.	In 2010-11 budget	http://www.mnre.gov.in/adm-approvals/solarhl-bank-schem.pdf
	National	Off-grid and Decentralised Solar Investments (part of Solar Mission)	Ministry of New and Renewable Energy to provide financial support through a combination of 30 per cent capital subsidy and/or 5 per cent low interest bearing loans. Capital subsidy of 90 per cent of the benchmark cost is available for special category states. Eligible investments include rooftop photovoltaic & small solar power generation, various off-grid solar photovoltaic systems, and off-grid and decentralised solar thermal applications. The program's budget is Rs.252 crore (approx A$58 million).	Approved July 2010 with funding to March 2013.	http://mnre.gov.in/adm-approvals/aa-jnnsm-2010-11.pdf http://www.mnre.gov.in/adm-approvals/aa-rpssgp-2010-11.pdf http://ireda.gov.in/pdf/Solar%20Off-Grid%20Refinance%20Scheme.pdf
	National	National Biogas and Manure Management Program	Subsidies to set up household biogas plants, mainly for cooking purposes and also for other applications to reduce use of LPG and other conventional fuels. Also aims to improve sanitation in villages by linking sanitary toilets with biogas plants. The budget for this program is Rs.562 crore (approximately A$126.4 million) over the 11th year plan.	Started in 1981 as part of the National Project on Biogas Development. Fully funded to the end of the 11th Plan.	http://www.mnre.gov.in/adm-approvals/biogasscheme.pdf
	State	Subsidy for battery operated vehicles	Buyers of battery operated vehicles receive 15 per cent subsidy on the costs of purchase and 12.5 per cent VAT reimbursement. The one time vehicle registration charge is also reimbursed giving a total subsidy of 29.5 per cent. This includes both cars and also motorbikes. Rs.4.12 crore (in the financial year 2008-09) has been spent on this program.	Announced in 2008 and appears to be ongoing.	http://www.delhi.gov.in/wps/wcm/connect/environment/Environment/Home/Climate+Change/Energy+Conservation/Battery+Operated+Vehicles
Feed-in tariff	National	NTPC Vidyut Vyapar Nigam (NVVN).	New architecture for the delivery of 1000 MW from grid connected solar projects under the first phase of the JNNSM. Under this scheme, NVVN will sell 'bundled power' to the state distribution companies where the bundle consists of solar PV/solar thermal power (50:50 ratio) it procures through competitive auction and an equivalent capacity of coal generated power. Press reports suggest that first round of (solar PV) competitive bids has led to a range of FITs in the region of Rs.10.95-Rs.12/kWh, with fears that this may be too low to allow the projects to proceed.	Projects under the first phase chosen in December 2010.	http://www.nvvn.co.in/Guidelines.pdf
	National	Power Purchase Tariff	Preferential (Feed-in) tariff for renewable energy. This is a single part tariff consisting of the return on equity, interest on loan capital, depreciation, interest on working capital, operation and maintenance expenses. Where a technology has a fuel cost component, a fixed cost component and a fuel cost component shall be determined. The Central Electricity Regulatory Commission (CERC) shall take into consideration any incentive or subsidy offered by the Central or State Government, including accelerated depreciation benefit if availed by the generating company while determining the tariff.	Terms and conditions for Tariff Determination from Renewable Energy Sources Regulations 2009 released September 2009.	http://www.cercind.gov.in/Regulations/CERC_RE-Tariff-Regualtions_17_sept_09.pdf

Policy type	Jurisdiction	Name	Description	Status and duration	References
	National	Generation Based Incentives (GBI) for Demonstration Program of Grid Interactive Solar Power Generation Projects	A GBI of a maximum of Rs.12/KWh is available for electricity generated from solar PV and a GBI of a maximum of Rs.10/KWh for electricity generated through solar thermal power plants (fed to the grid from a grid interactive solar power plant of a capacity of 1 MW and above). Plants with a minimum installed capacity of 1 MW per plant at a single location are eligible on a 'first come, first served' basis. There is a cap of 10 MW maximum cumulative capacity of grid interactive solar PV power generation projects in each State. Companies can avail of the accelerated depreciation arrangements or the GBI, but not both. Tariff is paid for 10 years with the intention that the total tariff received by producers (including state determined tariff) is at least Rs.15/kWh.	Announced January 2008.	http://www.mnre.gov.in/pdf/guidelines_spg.pdf http://mnre.gov.in/press-releases/press-release-02012008.pdf http://mnre.gov.in/annualreport/2009-10EN/Chapter%206/chapter%206_1.htm
	National	Generation Based Incentives (GBI) for Rooftop PV and Small Solar Power Generation Systems.	A GBI will be payable to the distribution facility for power purchased from eligible solar power projects equal to the difference between the tariff determined by the Central Electricity Regulatory Commission and the Base Rate (Rs.5.50/kWh (for financial year 2010-11)). The Base Rate applied to projects shall escalate by 3 per cent per annum. The calculated GBI for any given project will remain constant for a period of 25 years. There are two eligible types of projects: (1) projects with proposed installed capacity of a minimum of 100 kW and up to 2 MW and connected at below 33 kV; and (2) projects with proposed installed capacity of less than 100 kW and connected to the grid at LT level (400 V for 3-phase or 230 V for 1-phase). This GBI is part of the 'Rooftop Photovoltaic & Small Solar Power Generation Program' (which also incorporates the Off-Grid and Decentralized Solar application incentives mentioned in the capital subsidy section). Companies can avail of the accelerated depreciation arrangements or the GBI, but not both.The budget for this program is Rs.252.0 crore (approx A$58 million).	Approved June 2010. Projects should be designed for completion by March 2013.	http://mnre.gov.in/adm-approvals/aa-rpssgp-2010-11.pdf http://www.ireda.gov.in/Solar_GBI_09_02_2010.ppt#256,1,Proposed Guidelines for Small Solar Power Plants connected to 11 KV Grid under Jawaharlal Nehru National Solar Mission A Presentation by IREDA
	National	Generation Based Incentives (GBI) for Grid Interactive Wind Power Projects	A GBI will be provided to wind electricity producers at Rs.0.50 per unit of electricity fed into the grid for a period not less than four years and a maximum period of 10 years with a cap of Rs.62 lakh/MW. Incentive is over and above tariff approved by the CERC. SERCs (State Electricity Regulatory Commissions) will not take the GBI into account when calculating the tariff for wind power projects. Companies can avail of the accelerated depreciation arrangements or the GBI, but not both. To be eligible, new wind power projects must have at least 5 MW of grid-connected capacity, and must be installed at sites validated by the Centre for Wind Energy Technology.	Commenced December 2009. The GBI will continue until the end of the 11th Plan (mid 2012).	http://www.mnre.gov.in/gbi-scheme.htm http://ireda.gov.in/pdf/OPERATIONAL%20GUIDELINES%20for%20Wind%20GBI%20and%20AD%20as%20on%2026.05.2010.doc http://ireda.gov.in/pdf/GBI%20Projects.pdf
	Various states	Feed-in tariffs in states	Various states have announced feed-in tariffs. For example, Kerala has a solar generation tariff of Rs.15.31-Rs.17.91/kWh (inclusive of GBI) and Karnataka has set a feed-in tariff for solar plant and solar PV of Rs.3.40/kWh (exclusive of GBI).		http://www.erckerala.org/userFiles/634177281778750000_JawaharSolarOrder_04-08-10__FINAL_.pdf
Tax rebate or credit	National	Accelerated depreciation for selected renewable energy projects	Under the Income Tax Act, accelerated depreciation of 80-100 per cent on specified 'non-conventional renewable energy devices/systems' in the first year of installation of the projects. Independent power producers and FDI are not eligible for accelerated depreciation.		http://www.ireda.gov.in/incentives.asp http://mnre.gov.in/prog-biomasspower.htm http://ireda.gov.in/pdf/AD%20Projects.pdf
	National	Central Sales and General Sales Tax exemptions	Exemption/reduction in Central Sales Tax and General Sales Tax are available on sale of renewable energy equipment in various States.		http://www.ireda.gov.in/incentives.asp
	National	Customs duty concessions on the import of renewable energy equipment	Concessions on customs duty for the import of renewable energy equipment, including wind electric generators and parts and biogas generation machinery.		http://mnre.gov.in/prog-wind.htm
	In place in Kerala and Andhra Pradesh, and possibly other states.	Exemption for vehicle permit for battery/CNG and solar energy fuelled vehicles	This scheme encourages the use of battery, CNG and solar energy as an auto fuel by exempting vehicles using such fuel from the requirement of permit or fixation of fare by the State Government.		http://morth.nic.in/index2.asp?sublinkid=204&langid=2 http://www.keralamvd.gov.in/index.php?Itemid=91&id=45&option=com_content&task=view
	State	VAT subsidy to phase out older diesel light commercial vehicles	This scheme aims to phase out diesel light commercial vehicles (LCVs) over 15 years of age. Provides a subsidy equivalent to VAT (12.5 per cent) that will be provided on purchase of new LCVs.	Introduced in 2008. Duration uncertain.	
Tax exemption	Naitonal	Excise exemption on ethanol	Full excise exemption on ethanol (up to 5 per cent blends).		http://www.cbec.gov.in/excise/cx-tariff0910/chap27.pdf
	National	Biodiesel exemption from excise	Full excise exemption on biodiesel (up to 20 per cent blends).	Ongoing.	http://www.cbec.gov.in/excise/cx-tariff0910/chap27.pdf
	National	Tax holiday on profits from wind electric generators and biomass power cogeneration.	Tax holiday is allowed for 10 years for profits/gains from private wind electric generators, biomass power cogeneration and (probably) SHP projects.		http://ireda.gov.in/incentives.asp
	National	Excise exemption for renewable energy devices, including raw materials, components and assemblies.	Under this scheme, the Government has provided excise exemptions for parts and machinery used in renewable energy generation. Exemptions are provided on an item by item basis. In 2006, a large range of renewable energy equipment was made excise free. Furthermore, in the 2010-11 budget, the Government announced an exemption on machinery, instruments, and equipment and appliances required for the initial setting up of PV and solar thermal power generating units and 'specified inputs for the manufacture of rotor blades for wind energy generators'.		http://indiabudget.nic.in/ub2010-11/bs/speecha.htm http://www.cbec.gov.in/excise/cx-act/notfns-2k6/cex0606.pdf http://www.mnre.gov.in

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	State	CNG fuel for automotive use fully exempt from sales tax	To provide an incentive for vehicles to convert to CNG, the Delhi Government exempts CNG for automotive use from sales tax.	Ongoing.	
Preferential, low-interest or guaranteed loan	National	Accelerated development and deployment of solar water heating systems in domestic, industrial & commercial Sectors	This scheme provides loans repayable within five years for approved solar water heating systems. Interest rate subsidies vary depending on location and whether systems are for domestic/institutional or commercial use. Subsidies are 2 per cent for individuals, 3 per cent for instiutions and 5 per cent for commercial entities. The budget for this program is Rs.15.0 crore for 2010-11 (approx. A$3.4 million).		http://www.mnre.gov.in/adm-approvals/aa-solar-water.pdf
	National	Indian Renewable Energy Development Agency Limited (IREDA) loans for renewable energy projects	Loans are offered at more favourable interest rates then commercially available. Eligible applicants include incorporated bodies associated with the development of technologies pertaining to renewable energy and/or intending to set up manufacture of components/products/systems related to renewable energy. Eligible sectors include small hydro power, hydro projects above 25 MW, wind energy, bioenergy, solar energy, energy efficiency and energy conservation, biofuel/alternate fuels, and new and emerging technologies.		http://www.ireda.gov.in/pdf/Financing%20Norms.pdf http://www.ireda.gov.in/pdf/Policy%20on%20providing%20assistance.pdf http://ireda.gov.in/pdf/IREDA_ANNUAL_REPORT_2008-09.pdf Renewable Energy in India: Progress, Vision and Strategy
	National	Partial Risk Guarantee Fund	Provision of risk guarantee for Energy Service Companies.		
	National	Financing energy efficiency for SMEs	This project aims to increase demand for energy efficiency investments in target micro, small and medium enterprise clusters and to build their capacity to access commercial finance. This project is financed from local commercial sources through project development support and through deployment of performance linked grants for demonstration purposes. According to the World Bank, the budget for this program is US$59.3 million.	Approved by the World Bank on 27 May 2010, no closing date identified.	http://web.worldbank.org/external/projects/main?Projectid=P100530&theSitePK=40941&piPK=64290415&pagePK=64283627&menuPK=64282134&Type=Overview
Fuel or resource tax	State	Environmental cess (tax)	New Delhi imposed an 'environmental cess' (tax) of Rs.0.25/L on sale of diesel in the national capital region of New Delhi. The funds from the tax are hypothecated to an 'Air Ambiance Fund' to be utilised for development and use of Clean Air Technologies (for example, electric/hybrid vehicles and CNG conversions) by the Department of Environment and Department of Transport. Rs.38.5 crore (in the financial year 2008-09) and Rs.12.77 crore (up to September 2009) have been collected.	Commenced in 2008, appears to be ongoing.	http://www.delhi.gov.in/wps/wcm/connect/doit_pollution/Pollution/Home/Achievements
	National	Clean Energy Cess (tax) on coal, lignite and peat	The 2010-11 budget contained a levy of Rs.50/t of coal, lignite and peat applying to domestically produced and imported coal/lignite/peat. The tax is hypothecated to a National Clean Energy Fund (to fund research, innovation in clean energy technology and environmental remedial programs). The Central Board of Excise and Customs estimates expected earnings from the tax to be around US$500 million for the financial year 2010-11.	Announced in 2010-11 budget and came into force 1 July 2010.	http://moef.nic.in/downloads/public-information/India%20Taking%20on%20Climate%20Change.pdf http://www.cbec.gov.in/excise/cx-circulars/cx-circulars-10/circ-cec01-2k10.htm
	National & States	Excise tax	Fuel taxes consist of customs duties and excise duties (levied by Central Government) as well as sales taxes (levied by State Governments). Central Government taxes (combined) are 7.5 per cent plus Rs.28.70/L for motor spirits and 7.5 per cent plus Rs.8.20/L for diesel (HSD). Sales taxes vary by State. Kerosene is not taxed by the Central Government and LPG is only subject to a 5 per cent customs duty. State taxes vary by State.	Ongoing.	http://petroleum.nic.in/petstat.pdf Central Board of Excise and Customs
Other tax	State - includes Karnataka, Maharashtra, Andhra Pradesh, Tamil Nadu, Rajasthan, Himachal Pradesh.	Green Tax (on old vehicles)	The details of the tax vary by State and generally applies at different levels for commercial and non-commercial vehicles (also differs for two and four wheels). The tax ranges from (approximately) Rs.200-Rs.3500 per annum (varies by State and vehicle type). The tax is generally applied to commercial vehicles older than sevent to eight years and private vehicles older than 15 years (can vary slightly by State).	Commencement date varies by State. Ongoing.	http://www.karnataka.gov.in/dpal/pdf_files/MOTOR%20VEHICLES%20TAXATION%20ACT-new%20(Final).pdf http://envis.maharashtra.gov.in/envis_data/?q=eepmnws_aug10 http://www.transport.rajasthan.gov.in/PDF%20Files/Tax%20Notification/24.pdf
	National	Vehicle Excise	Central excise is an indirect tax on goods manufactured in India. The national excise duty has been set to give an advantage to small cars - 10 per cent excise on small cars (less than 1.2L petrol or 1.7L diesel engines) and 22 per cent + Rs.15 000 on bigger cars and SUVs (announced in 2010-11 budget). All electric vehicles (2, 3 and 4 wheel) have an excise tax of 4 per cent (increased in 2010-11 Budget from 0 per cent). This also applies to parts for use in the manufacture of electrically operated vehicles. Hydrogen vehicles based on fuel cell technology are taxed at concessional rate of 10 per cent and hybrid kits for conversion of fossil fuel vehicles to hybrid vehicles are taxed at 5 per cent (announced 2011-12 budget). This has created an incentive for small diesel cars. However, clean diesel fuel and technologies are not yet widely available in India.		http://www.siamindia.com/scripts/excise-duty.aspx 2008-09: http://www.cbec.gov.in/budget0809/exnotecex.pdf 2009-10: http://indiabudget.nic.in/ub2009-10/cen/exnotecex.pdf 2010-11: http://indiabudget.nic.in/ub2010-11/cen/exnotecex.pdf 2011-12: http://indiabudget.nic.in/ub2010-11/cen/exnotecex.pdf
	New Delhi	Congestion charging zone	Introduced for the Commonwealth games and maintained in high traffic areas.	Implemented in 2010	http://www.india-server.com/news/delhi-people-to-pay-to-drive-in-26196.html
Regulatory instruments					

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Renewable energy certificate scheme	National - but set by each State Electricity Commission	Renewable Purchase Obligations (also known as Renewable Portfolio Standards) by State	State Electricity Commissions specify Renewable Purchase Obligations (RPOs) which indicate a percentage of total electricity consumption that must be purchased from renewable sources (with percentages varying by renewable energy source). The Electricity Act states that the RPOs should be progressively increased. Some SERCs also have preferential grid connection and transportation charges and guaranteed buy-back provisions for certain types of renewable energy such as biomass power and cogeneration projects. A Renewable Energy Certificates trading scheme for RPOs is currenty being developed through the Forum of Regulators (group of all State Energy Regulatory Authorities) in order to assist generators to meet State RPOs (as some States have better availability of renewable energy options than others). The price of RECs will be determined in the market subject to a 'forbearance' (ceiling) price set by the National Load Dispatch Centre (the newly appointed Central agency for implementation of RECs).	Implemented in 2003 and ongoing. Under the Solar Mission there is mention of a specific solar RPO, however, this is yet to be implemented.	http://www.cercind.gov.in/Regulations/Final_SOR_RE_Tariff_Regulations_to_upload_7_oct_09.pdf http://www.cercind.gov.in/Regulations/REC_Amemdment_SOR_27_9_2010.pdf http://www.cercind.gov.in/Regulations/CERC_Regulation_on_Renewable_Energy_Certificates_REC.pdf http://www.cercind.gov.in/Regulations/REC_Amemdment_Regulation_29_9_2010.pdf
Fuel content mandate	National	Ethanol Blending Program	Mandate requiring 5 per cent ethanol blend in petrol (imported ethanol cannot be used to meet this quota). Prior to 2008, various mandates existed at State level, but they were not enforced due to insufficient volumes of ethanol produced. In 2008, the Government introduced the mandate to the entire country (but still not enforced where supply is insufficient to meet mandate).	Ongoing.	http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_New%20Delhi_India_7-1-2010.pdf
Energy efficiency regulation	National	The Energy Conservation Building Code (ECBC)	Started in May 2007, the ECBC sets mandatory standards for commercial buildings or building complexes that have a connected load of 500 kW or greater or a contract demand of 600 kVA or greater. The code is also applicable to all buildings with a conditioned floor area of 1000 square metres (10 000 square feet) or greater. The code is recommended for all other buildings. State Governments can modify ECBC to suit their local needs.	Ministry of Power launched ECBC on 27th May 2007 (initially voluntary) and it is now ongoing.	http://eco3.org/about-us/ http://www.unep.org/climatechange/Portals/5/roap-network/Experience%20of%20India%20on%20Policies%20and%20Schemes%20for%20Energy%20Conservation%20and%20Efficiency.pdf http://bee.gov.in/schemes/documents/ecbc/ECBC-userguide.pdf http://www.spaenvis.nic.in/pdfs/ECBC.pdf
	National	Perform, Achieve and Trade (PAT) part of National Mission on Enhanced Energy Efficiency	Mandates approximately 700 of the most energy intensive industrial units and power stations in India to reduce energy intensity by a specified percentage (depending on current level of efficiency). Units that achieve reductions above their mandated amount receive Energy Savings Certificates (ESCerts) and these can be traded with other units. Further units are to be added over time. The firms included in the scheme are responsible for around half of India's GHG emissions	National Mission on Enhanced Energy Efficiency was announced in June 2008. BEE is currently undertaking work to implement PAT.	http://mnre.gov.in/press-releases/press-release-24062010.pdf http://www.bee-india.nic.in/NMEEE2.ppt#256,1,National Mission for Enhanced Energy Efficiency http://moef.nic.in/modules/about-the-ministry/CCD/twenty_CC_initiatives.pdf
	National	Green Rating for Integrated Habitat Assessment (GRIHA) classification for government buildings	All public and government buildings must mandatorily meet classification of three or four stars under the GRIHA rating system (see below more details about GRIHA).		http://www.mnre.gov.in/pdf/mnre-paper-direc2010-25102010.pdf http://www.grihaindia.org/index.php
	National	Vehicle fuel efficiency standards	The Government will introduce fuel efficiency standards for vehicles (varying by vehicle type and size). A labelling program will also be introduced in conjunction with this program. The BEE has been mandated by the Prime Minister's Office to stipulate the norms under the Energy Conservation Act 2001. In December 2010, it was decided that the legislation would be similar to the US CAFE legislation where fleet average fuel economy is measured and updates will be aligned with the Bharat air quality emission updates (2015, 2020).	Standards have been in development for a while. Likely to become law in 2011.	http://moef.nic.in/modules/about-the-ministry/CCD/twenty_CC_initiatives.pdf
	National	Municipal Demand Side Management	The Bureau of Energy Efficiency has started a program to give energy audits to 175 municipalities around India. Energy service companies and utilities are then encouraged to take up the implementation of demand side management in the municipality.		http://www.bee-dsm.in/PoliciesRegulations_1_4.aspx#L7
	National	Agricultural Demand Side Management	Energy service companies will be tasked with trageting agriculture electricity consumption through the replacement of inefficient irrigation pumps with star rated new pumps.		http://www.bee-india.nic.in/schemes/documents/agricultural_and_municipal_dsm/adsms/Booklet1Feb2009.pdf http://www.bee-dsm.in/PoliciesRegulations_1_4.aspx#L8
Direct government expenditure					
Government procurement - general	Andhra Pradesh	CNG buses in Andhra Pradesh	Andhra Pradesh State Road Transport Corporation (APSRTC) has received a directive from the Andhra Pradesh State Government to ensure that at least one-third of the 6000 buses which it intends to purchase over the next 36 months operate on compressed natural gas (CNG)		http://timesofindia.indiatimes.com/city/hyderabad/Govt-directs-APSRTC-to-ensure-new-buses-should-run-on-CNG/articleshow/7428365.cms

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Government investment - infrastructure	National	Solar cities	During the 11th plan, India will develop up to 60 Solar Cities. At least one city in each state, up to a maximum of five cities in a State, will be supported by the Ministry. Furthermore, two cities will be 'Model Solar Cities' (with financial support up to a maximum of Rs.9.50 crore (approximately A$2.4 million) on 50 per cent cost sharing basis from respective Municipal Corporation/City Administration/State Government). Solar Cities will commit to up to 10 per cent of energy consumption of the city to be met through renewable energy and energy efficiency measures. Fifty per cent of the cost will be shared by the Ministry. Major solar energy systems will be installed including streetlights, garden lights, traffic lights, hoardings, and solar water heaters. Energy Efficient Green Buildings will also be promoted on a large scale in the city. Total budgetary cost for this program is Rs.30 crore (A$6.8m).	Commenced February 2008 and continues throughout the 11th plan period (2007-2012).	http://mnre.gov.in/press-releases/press-release-18022009.pdf http://mnre.gov.in/pdf/city-scheme.pdf
		Metro Infrastructure	According to the Ministry of Urban Development, four new metro projects are under construction and planned as joint ventures in Delhi, Chennai, Kolkata and Bangalore. IIFCL was reported to be considering supporting a metro project in Jaipur.		http://www.urbanindia.nic.in http://news.webindia123.com/news/articles/India/20110210/1685912.html
		Coal-fired generation rehabilitation	Rehablitation and modernisation of coal fired generation fleet in order to improve energy efficiency. Pilot phase of project will renovate and modernize 640 MW of old coal-fired power generation capacity to demonstrate energy efficient rehabilitation approaches. It will go beyond the typical Indian practice, of restoring original generation capacity, life-extension, and improving availability, by also modifying (or replacing) some equipment and systems to enable the unit to operate with higher fuel efficiency. Initial pilot phase of project financed by World Bank loan (US$180 million) with supporting technical assistance grant from GEF.		http://www.worldbank.org.in/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/INDIAEXTN/0,,contentMDK:22216278~pagePK:141137~piPK:141127~theSitePK:295584,00.html
Government investment - environment	National	Compensatory Afforestation Fund	The fund is financed through monies from diversion of forestland to non-forest uses. Each state has their own fund and the Central Compensatory Fund Management and Planning Authority oversees the funds nationally.	The fund commenced in 2001 and the agreement on how to disburse funds was formed in 2009.	http://pib.nic.in/release/release.asp?relid=36461
Support for research and development					
R&D - general and demonstration	National	Implementation of Technology Evaluation Projects on Large Area Solar Dish Concentrator (ARUN-160) for Industrial Process Heat Systems	Supports the installation and commissioning of ARUN-160 solar dish concentrators for various industrial process heat applications in order to evaluate the technology under actual field conditions and obtain data on reliability and performance. The project target is 10 technology evaluation projects, involving up to a maximum of 20 solar dish concentrators.A fixed financial support of Rs.12.0 lakh (approximately A$275 000) will be provided for each ARUN-160 dish involved in a project. The user organisation will meet all other costs.The budget for this program is Rs.64.8 crore (approximately A$14.9 million).		http://www.mnre.gov.in/adm-approvals/aa-st-tep-lasdc-2010-11.pdf
	National	Demonstration Program on Tail-end grid connected Solar Power Plants	Demonstration program to connect solar power plants at the 'tail-end' of the grid to provide voltage support and additional power for day time use. Available funding is up to 50 per cent of the ‘installed cost’ of the solar power plant (excluding cost of land, extension of line for power evacuation and civil works) or a maximum of Rs.10 crore/MW of solar capacity. Eligible parties include any company or Electricity Board that is authorised in the States/UTs to distribute or generate electricity. State Nodal Agencies (SNAs) are also eligible, provided they connect and feed power to the tail-end grid.		http://www.mnre.gov.in/adm-approvals/solarpower-280209.pdf
	National	Demonstration of Integrated Technology Package on Medium-size Biogas-Fertilizer Plants for Generation, Purification/Enrichment, Bottling and Piped distribution of Biogas	Support for 50 per cent of the cost of the technology project. The balance of the cost is required to be invested/mobilised by the entrepreneur/developer. However, at least 20 per cent of the cost of the project is to be met by the entrepreneur/user agency (with their own funds, and not from other government or NGO funding programs). The capacity of biogas projects could be 200, 400, 500, or 1000 m^3 biogas per day and multiples thereof, depending on the availability of suitable biomass feed-materials and cattle-dung.		http://www.mnre.gov.in/pdf/bgfp.pdf
		Grants to support research, design and development in new and renewable energy	Financial support ranging from 50-90 per cent of project cost is provided for collaborative Research, Design, Development and Demonstration projects in association with industry. A total of around 90 R&D projects with a budget of around Rs.1.4 billion have been sanctioned during the period 2007-2010.		http://www.mnre.gov.in/pdf/mnre-paper-direc2010-25102010.pdf
		Renewable Energy Incubation Scheme	This scheme provides support for entrepreneurs, including internship/grooming programs, evaluation of technologies being developed in various labs and patent search, and also by providing initial support for setting up enterprises.		http://www.mnre.gov.in/pdf/mnre-paper-direc2010-25102010.pdf
Other					
Labelling scheme	National	National Energy Labelling Program	This program phases in mandatory labelling. Eleven equipment and appliance types are currently included. There is mandatory labelling for frost free fridges, some fluorescent lights, air conditioning and distribution transformers.There is voluntary labelling for fridges, televisions, fans, pumps, industrial motors, water heaters and gas stoves. This program has also been committed to apply to passenger cars and heavy commercial vehicles.	National Energy Labelling Program launched 18 May 2006. Mandatory coverage of items (in description) on 7 January 2010.	http://www.bee-india.nic.in/schemes/standard_and_labeling.php http://www.unep.org/climatechange/Portals/5/roap-network/Experience%20of%20India%20on%20Policies%20and%20Schemes%20for%20Energy%20Conservation%20and%20Efficiency.pdf

Policy type	Jurisdiction	Name	Description	Status and duration	References
	National	Green Rating for Integrated Habitat Assessment (GRIHA) of Buildings	GRIHA is a five star rating tool that helps assess the performance of all types of buildings against nationally acceptable benchmarks. Environmental performance is evaluated over a building's life cycle. The appraisal may be revised every three years to take into account scientific developments.		http://www.grihaindia.org/index.php http://teriin.org/
		Vehicle labelling	The Society of Indian Automobile Manufacturers (SIAM) has introduced a Voluntary Labelling Program. The program, announced in September 2008, called for all member companies to make a voluntary disclosure of fuel economy by end of March 2009.	Vehicle economy labelling now falls under legislation and will be introduced in 2011.	http://www.siamonline.in/Fuel_Economy/Fuel-consumption.pdf http://www.deccanherald.com/content/125153/in-2011-cars-come-star.html
Advertising or educational scheme	National	National Green Corps	This project aims to provide environmental education opportunities for school children and is operated through 'Eco-clubs' to be formed in member schools. There will be a District Implementation and Monitoring Committee to supervise, organise training for in-charge teachers, and monitor periodically the implementation of the scheme at the District level. A State Steering Committee oversees the implementation of the program.	Has been going since at least early 1990s.	http://moef.gov.in/divisions/ee/ngc/ngc_brochure.html
	National	Energy Conservation Awards	The Ministry of Power instituted the National Energy Conservation Awards, coordinated by the Bureau of Energy Efficiency, to recognise industrial units that have made special efforts to reduce energy consumption.	Ongoing.	http://www.bee-india.nic.in/NMEEE2.ppt
Broad target or intergovernmental framework		Short Term 'Clean Development Mechanism' Target	India aims to neutralise 10 per cent of its emissions by 2012 through the application of Clean Development Mechanism (CDM) projects .		http://moef.nic.in/downloads/public-information/24_Recent_Initiatives_CC.pdf
	National	National Action Plan of Climate Change (NAPCC)	This plan consists of eight National Missions (the missions are listed below) form the core of the National Action Plan, representing long-term integrated strategies for achieving key climate change goals (some programs may already be part of current actions). The plan's target is 5 per cent renewable energy purchase for 2009-10 with the target increasing 1 per cent each year for the next 10 years.	NAPCC was announced 30 June 2008.	http://pmindia.nic.in/Pg01-52.pdf
	National	Jawaharlal Nehru National Solar Mission (JNNSM) (Part of NAPCC)	A three-phase approach, spanning the remaining period of the 11th Plan and first year of the 12th Plan (up to 2012-13) as Phase 1, the remaining four years of the 12th Plan (2013-17) as Phase 2 and the 13th Plan (2017-22) as Phase 3. Mission targets include: the creation of a policy framework for the deployment of 20 000 MW of solar power by 2022; ramping up the capacity of grid-connected solar power generation to 1000 MW within three years (by 2013); an additional 3000 MW by 2017 through the mandatory use of the RPO by utilities backed with a preferential tariff; promotion programs for off-grid applications, reaching 1000 MW by 2017 and 2000 MW by 2022; and the deployment of 20 million solar lighting systems for rural areas by 2022. The first phase (up to 2012- 2013) will focus on capturing the 'low-hanging' options in solar thermal power, promoting off-grid systems to serve populations without access to commercial energy, and modest capacity addition in grid based systems. A budget of Rs.4337 crore (approximately A$976 million) has been approved for the activities proposed under the first phase of the Mission (until Ma	Announced in 2008,running until 2022.	http://mnre.gov.in/pdf/resolution-jnnsm.pdf
	National	National Enhanced Energy Efficiency Mission (Part of NAPCC)	This Mission consists of four new initiatives in addition to the programs on energy efficiency currently being pursued. The flagship of the mission is the Perform Achieve and Trade Scheme. The second initiative is Market Transformation for Energy Efficiency, which includes accelerating the shift to energy efficient appliances in designated sectors through innovative measures to make the products more affordable. The third initiative is the Energy Efficiency Financing Platform, which allows for the creation of mechanisms that would help finance demand side management programs in all sectors by capturing future energy savings. The final initiative is the Framework for Energy Efficient Economic Development, to develop two fiscal instruments to promote energy efficiency - the Partial Risk Guarantee Fund and Venture Capital Fund for Energy Efficiency. The budget for this Mission is Rs.235.35 crore (approximately A$53 million).	Announced in 2008,running until 2022.	http://mnre.gov.in/press-releases/press-release-24062010.pdf
	National	National Mission for Sustainable Habitat (Part of NAPCC)	This mission aims to make 'habitat sustainable' through improvements in energy efficiency in (residential and commercial) buildings, management of water, waste water and solid waste (taking into account potential for recycling and energy generation), and encouragement for a shift to public transport. Three new initiatives include the Energy Conservation Building Code, recycling of material and urban waste management and better urban planning.	Announced in 2008,running until 2022.	http://pmindia.nic.in/Pg01-52.pdf
	National	National Mission for a Green India (Part of NAPCC)	The objectives of the Mission are: 1) Increased forest/tree cover on five million hectares of forest/non-forest lands and improved quality of forest cover on another five million hectares (a total of 10 million hectares); 2) improved ecosystem services including biodiversity, hydrological services and carbon sequestration; 3) increased forest based livelihood income for about three million households living in and around the forests; and 4) enhanced annual CO_2 sequestration by 50 to 60 million tonnes in the year 2020. The budget for this Mission is Rs.46 000 crore over 10 years (approximately A$10.2 billion).	The implementation period of the Mission will spread over 10 years, coinciding with the 12th and 13th five year plan periods. In 2010-11, State Action Plans will be put in place and 2011-12 will be a preparatory phase, with the program commencing in 2013.	http://moef.nic.in/downloads/public-information/GIM-Report-PMCCC.pdf

Policy type	Jurisdiction	Name	Description	Status and duration	References
	National	National Mission for Strategic Knowledge for Climate Change (Part of NAPCC)	This Mission will fund research into various aspects of climate change, including the socioeconomic impacts of climate change. It will support the establishment of dedicated climate change related academic units and create a Climate Science Research Fund. Furthermore, private sector initiatives will be encouraged through venture capital funds.	Announced in 2008,running until 2022.	http://www.dst.gov.in/scientific-programme/NMSKCC_July_2010.pdf
	National	State Action Plan on Climate Change	Each of the 28 states in India will produce a State Action Plan on Climate Change. The final draft is expected 31 March 2011. Plans should cover forests, wildlife and biodiversity, agriculture, horticulture and fisheries, water, health, energy, industry, urban development and rural development. To date, two states have published their action plans (Delhi and Orissa).		http://www.delhi.gov.in/wps/wcm/connect/environment/Environment/Home/Climate+Change/ http://www.delhi.gov.in/wps/wcm/connect/9b217b004041c62ea420ac34262e20fd/Climate_Change_Agenda+09-12_+Booklet_Env.pdf?MOD=AJPERES&CACHEID=9b217b004041c62ea420ac34262e20fd http://orissa.gov.in/portal/occap.pdf
	National	Participatory Forest Management Strategy	India's forest conservation efforts include protecting existing forests, putting checks on the change of forest land to non-forestry purposes, encouraging farm forestry/private area plantations, expanding the protected area network and controlling forest fires. The National Forestry Action Programme has been formulated for sustainable forest development and to bring one-third of the country's geographical area under forest/tree cover as mandated in the National Forest Policy 1988. A major program of afforestation is being implemented with participation from the people under the Joint Forest Management. The National Finance Commission has allocated nearly US$1 billion for conservation in highly forested provinces of India.	Ongoing	http://envfor.nic.in/naeb/naeb.html
	National	National Policy on Biofuels	Key features of the policy include an indicative target of 20 per cent blending of biofuels by 2017, a focus on developing non-food feedstocks for ethanol and biodiesel, government regulated prices for the 'minimum support price' for non-edible oil seeds to be used to produce biodiesel and a 'minimum purchase price' for ethanol and biodiesel. Funding for research, development and demonstration is to be provided, with focus on plantations, processing and production of biofuels, including second generation biofuels.	Introduced in 2009. Ongoing.	http://www.mnre.gov.in/policy/biofuel-policy.pdf

Japan

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Explicit carbon prices					
Emissions trading scheme - cap and trade	National	National Emissions Trading Scheme	On 28 December 2010, Reuters reported that the Japanese government had postponed their plans for a national ETS due to opposition from business groups. The 'Bill of the Basic Act on Global Warming Countermeasures' introduced in March 2010, was not passed into law by the end of 2010 and thus will have to be amended before its main provisions are signed into law. The governing party announced in December 2010 that it would submit a bill for the introduction of an ETS separately to a bill for the introduction of a Carbon Tax and Feed-in Tariff.	Committed, but unclear whether it will be implemented.	http://www.env.go.jp/en/earth/cc/bagwc/overview_bill.pdf http://www.reuters.com/article/2010/12/28/us-climate-japan-idUSTRE6BR06120101228
Emissions trading scheme - baseline and credit	Metropolitan government	Tokyo ETS	Mandatory baseline and credit program based on energy consumption only (not direct emissions). The scheme covers approximately 1400 large installations, including 1100 office buildings and 300 factories. Participating entities represent less than 1% of businesses in Tokyo but emit about 40% of all CO_2 in this sector. The baseline for emissions reductions is the average emissions from any three consecutive years in the period 2002–2007. Fines are imposed on those who do not meet their targets and fail to purchase credits to cover the shortfall (credits from Kyoto Protocol are not eligible). The amount of each fine is ¥500 000 (approximately A$6200), coupled with an additional emissions reduction obligation beyond the shortfall itself. Credits purchased from renewable energy providers will count at 1.5 times the actual carbon saved.	Commenced on a voluntary (trial) basis from 2002 and became mandatory in 2010. Ongoing.	http://knowledge.allianz.com/climate/business/?586/japan-cap-trade-carbon-market-interview-miyazawa
	Regional government	Saitama ETS	Saitama Prefecture, a Japanese regional government, has established a very similar cap and trade scheme to the Tokyo Metropolitan government. The Saitama scheme will cover about 600 large installations based on the same criteria as Tokyo. However, unlike the Tokyo scheme, there is no financial penalty for non-compliance. The Tokyo and Saitama schemes will be linked, with credits eligible for use in both schemes (with some minor restrictions) from January 2012.	The first compliance period will start on 1 April 2011.	http://www.eco-business.com/news/2010/sep/15/tokyo-saitama-combine-carbon-emissions-trading-mar/
Emissions trading scheme - voluntary	National	Japan's Voluntary Emissions Trading Scheme (JVETS)	JVETS is a voluntary program where companies can pledge to reduce emissions relative to their average in the previous three years. Participating firms are able to choose their own targets and must either reduce emissions in line with their target or purchase allowances. A subsidy is provided such that one third of abatement costs are borne by the government, the subsidy is returned if the pledged abatement is not achieved. As of 2009, there were 232 companies participating in the JVETS scheme. The budget for the subsidy was approximately ¥1.2 billion for FY 2010 (approximately A$14 million).	Launched in 2005, ongoing.	Ministry of Environment (MoE) Japan
	National	Experimental introduction of an integrated domestic market for emissions trading	This is a voluntary program that is linked, in part, to the Voluntary Action Plan. Participating firms take on an emissions target, either on an absolute or emissions intensity basis. The target can be met through reducing emissions or purchasing credits (either through the 'Domestic CDM' scheme or Kyoto Protocol). The 'Domestic CDM' scheme is a voluntary credit mechanism where credits are created through collaborative projects between large enterprises and small and medium-sized enterprises. A total of 501 participants adopted targets as of December 2008, 50 of whom were designated to take part in trading.	Implemented through the Action Plan for Achieving a Low-carbon Society (agreed by Cabinet on July 2008). Commenced in October 2008. Not clear if still in operation.	Ministry of Environment Japan

Policy type	***Jurisdiction***	***Name***	***Description***	***Status and duration***	***References***
Carbon tax	National	Special Provision on Taxation for Global Warming Countermeasure	A tax of ¥2400 (approximately A$29) per tonne of CO_2 on fossil fuels, including transport fuels has been proposed. Tax on gasoline, light oil, and jet fuel would be initially zero. Relief for specific industries is under consideration. This measure imposes an additional tax on current Petroleum and Coal Tax rates (see Petroleum and Coal Tax for further details), based on CO_2 emission volume of each fossil fuel category. The tax will increase in 3 steps to April 2015: Crude oil, petroleum products: ¥760 per kilolitre (this will increase the tax on oil from ¥2040 to ¥2800 per kilolitre); Gaseous hydrocarbons: ¥780 per tonne; Coal ¥670 per tonne. In addition, tax exemptions and tax refunds will be given in some necessary areas. Various support measures will also be implemented to cut costs for fuel production and distribution, and to stabilise fuel supply. MoE expects ¥35.7 billion in tax receipts for the second half of FY2011 (the first 6 months of the carbon tax). The tax rate will be increased in April 2013 and April 2015. Both MoE and METI noted that in FY2015 they expect ¥240 billion in tax revenues.	Initially proposed in 2009. Government has signalled that it intends to introduce this as part of a comprehensive tax reform in 2011. MoE advises that the bill is under discussion at the Diet and is intended to be introduced in October 2011 (as of February 2011).	Ministry of Environment Japan
Subsidies and taxes					
Capital subsidy	National	Subsidies for Photovoltaic Generation	Capital subsidies for the installation of solar PV systems in residential buildings. In fiscal year 2009, the subsidy was ¥70 000/kW of solar PV installed (reduced to ¥48 000/kW in 2011). The budget was ¥20.05 billion from April 2009 to January 2010. METI advises a budget of ¥34 900 million for FY2011, which is expected to support around 179 000 projects.	Applications opened 1 April 2009 and closed 29 January 2010.	http://www.iea.org/textbase/pm/?mode=cc&id=4230&action=detail
	Metropolitan government	Subsidies for Photovoltaic Generation	Capital subsidies for the installation of solar PV systems in residential buildings, paid at the rate of ¥100 000/kW. This subsidy is provided in addition to the national subsidies listed above.	Introduced in April 2009.	
	National	Project for promoting the introduction of fuel consumption efficiency (motor vehicles)	The provision of grants for the installation of idle reduction devices in cars with the aim of improving energy efficiency in the transport sector. Grants are available for new or retrofit technologies and pay for half of the technology's marginal cost.	Commenced in 2007 (3,622 grants issued during 2007 fiscal year).	http://www.asiaeec-col.eccj.or.jp/brochure/pdf/fs-subsidy.pdf
Feed-in tariff	National	Buy-back program for solar photovoltaic generation	Electricity utilities are required to purchase excess electricity from solar PV systems exported to the grid. A fixed tariff is provided for 10 years (at rates of ¥20–45/kWh for systems installed in fiscal year 2009 (¥32–42/kWh in fiscal year 2011).	The government has proposed that these existing feed-in tariffs for solar PV be replaced by new feed-in tariffs. The new system will cover many types of renewable energy, including wind and geothermal, but will give preferential treatment to Solar PV in an attempt to create a first-mover advantage. It is reported that the bill to establish the new FIT system will be submitted to the Diet during 2011. The existing FIT was announced and legislated in August 2009 and came into force on 1 November 2009.	

Policy type	Jurisdiction	Name	Description	Status and duration	References
	National	Japan's FIT system - Broader buy-back program for other renewable energy types	In July 2010, METI announced key elements of a new feed-in tariff (FIT). METI advise that 'Japan's FIT system' would include electricity from PV generation, wind generation, biomass generation, medium and small-sized hydro generation (stations up to 30MW capacity) and geothermal generation (at rates of ¥15-20/kWh for 15 to 20 years). The proposed FIT provides special treatment for solar energy tariffs and METI expects that most of the additional renewable energy will be solar energy. This scheme is intended to replace the existing Renewable Portfolio Standards. The estimated total funds required for the program is between ¥460 billion and ¥630 billion. METI notes that 10 years after the introduction of the system, the cost to households (where electricity of 300kWh is consumed per month) is expected to be ¥150 to ¥200 per month.	Japan's new FIT system is still at the proposal stage and is to be presented to the Diet (parliament) in 2011. The government intends a series of laws to be passed during the ordinary parliamentary session in 2011 and become effective by April 2012.	
Tax rebate or credit	National	Tax scheme to promote investments in structural reforms of energy supply and demand	This tax scheme is available for businesses (industrial and commercial sectors) that acquire the specified energy conservation equipment (for example, highly efficient air-conditioning systems, high insulation window facilities, and light-emitting diodes) for which a special depreciation (an additional 30% of the equipment acquisition cost) will be applied. For small and medium-sized businesses, a tax deduction (7% of the equipment acquisition cost) is available instead of the special depreciation. This tax scheme was introduced to promote investment in the installation of equipment that facilitates the rational use of energy resources in the reform of the energy demand-supply structure. Tax deduction and special depreciation owing to this tax scheme in FY2010 is estimated at ¥48.7 billion (estimate by Ministry of Finance).		
	National	Tax incentives for fuel-efficient low emissions vehicles	The automobile tax is reduced by 25-50% depending on vehicle fuel efficiency and exhaust emission levels. The acquisition tax (imposed when purchasing a new car) is exempted for 'alternative energy next-generation vehicles' and is reduced by 50-75% for passenger cars and heavy-duty vehicles depending on energy efficiency and exhaust emissions. The tonnage tax (when a car undergoes mandatory inspection every 1-3 years) is also reduced in a similar fashion to the acquisition tax. An additional 10% is added where vehicle is old. MoE advises that revenue foregone from these tax concessions are ¥22 billion for FY 2009 (Automobile tax) and ¥17 billion for FY 2008 (Acquisition tax).	Ongoing since 2001. The acquisition and tonnage tax breaks are set to be phased out in first half of 2012.	
	National	Reduction in fixed asset taxes on biofuel production facilities	Implemented under the Law Concerning the Promotion of the Utilisation of Agricultural, Forestry and Fisheries Biomass as Raw Materials for Biofuels in 2008. This scheme reduces fixed asset taxes on biofuel production facilities by 50% over 3 years.	Introduced in 2008.	
	National	Eco Car Subsidy	New vehicles that have lower air quality emissions than TopRunner standards are eligible for reductions in acquisition tax and a one time reduction in the tonnage tax. Hybrid, plug-in hybrid, clean diesel, electric and natural gas vehicles are exempted from taxation. Heavy vehicles that meet fuel economy and emission standards receive a 1-2 per cent reduction in the acquisition tax of new vehicles. For the FY2009-10, the purchase of used cars meeting these requirements are eligible for a subsidy of up to ¥300,000 (A$3,600).	Came into effect on 1 April 2009 and was expected to run until 31 March 2012. However, the incentive ended in September/October 2010.	http://www.jama-english.jp/asia/news/2009/vol36/index.html
Tax exemption	National	Excise concessions on biofuels	Ethanol that is blended with petrol is exempt from fuel excise (¥53.8/litre for petrol)	Commenced in May 2008 and in effect until March 2013.	http://www.mof.go.jp/english/tax_policy/publication/taxes2010e/taxes2010e_f.pdf
Preferential, low-interest or guaranteed loan	National	Premium Loan for energy efficient retrofits/construction for housings	The Japan Housing Finance Agency (JHF) (previously Government Housing Loan Corporation, GHLC) allows for lower interest rates and preferential loans to be provided for energy efficient houses.	Ongoing	http://www.jhf.go.jp/english/about.html

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Other subsidy or grant	National	Eco-Lease Subsidy	MoE subsidises 3 per cent of the lease fee for low-carbon installations which small and mid-sized enterprises or households lease from private businesses.	According to MoE, this will be introduced in budget year 2011.	From the Ministry of Environment, Japan.
	National	Interest Subsidy for green investment	MoE, through financial institutions which conduct environmental screening, provides 1 per cent of interest subsidy on green investment loans (energy efficiency), on the condition that 5 per cent of greenhouse gas emissions reductions will be achieved within five years. MoE advises that this program has a budget of ¥1 billion for 2011.	Introduced in budget year 2007. Ongoing	From the Ministry of Environment, Japan.
	National	Eco-Point Program	This program has two streams: (1) encourage the purchase of energy efficiency appliances (such as TVs and air-conditioners) by awarding 'eco-points' depending on efficiency performance; and (2) encourage 'eco-friendly' house renovation (for example, improvement of thermal insulation of windows, installation of exterior-walls, ceiling or floor heat insulation and 'eco-friendly' house construction) such that Top Runner standards or energy saving standards are met. 'Eco-points' can then be used to buy other goods and services nation-wide. MoE advises the budget is as follows (1) Appliance component: Budget of ¥693 billion (approx A$8.2 billion) (2) Building component: Budget of ¥244 billion (approx A$2.9 billion).	First stream launched in May 2009 (as part of fiscal stimulus package), re-launched in April 2010 and January 2011 (with refined rules) and set to end in March 2011. Second stream launched in December 2009 (as part of fiscal stimulus package), re-launched in January 2011 and set to end in December 2011.	
Fuel or resource tax	National	Petroleum and coal tax	Tax on imported fossil fuels, including coal, petroleum and natural gas. Both refined and unrefined imports are taxed. Current tax rates are ¥700/t of coal, ¥1080/t of natural gas and ¥2010/kL of petroleum. These rates will be increased between 2013 and 2015 as part of the 'Special Provision on Taxation for Global Warming Countermeasure', with the rate of increase based on the CO2 emissions content of each fuel.	The coal and petroleum tax is already in place and will be increased from October 2011 (will increase each year until 2015). This increase will occur as part of the Tax for Measures against Global Warming	http://www.mof.go.jp/english/tax_policy/publication/taxes2010e/taxes2010e_f.pdf
	National	Fuel taxes	Japan levies two taxes on petrol (the Gasoline Tax and Local Gasoline Tax), at rates of ¥48.6/L and ¥5.2/L respectively. In addition, there is a Diesel Handling Tax of ¥32.1/L and a tax on LPG of ¥17.5/kg.	Ongoing	http://www.mof.go.jp/english/tax_policy/publication/taxes2010e/taxes2010e_f.pdf
Regulatory instruments					
Renewable energy certificate scheme	National	Renewable Portfolio Standard	Electricity retailers must generate or purchase a certain amount of renewable energy each year (compliance can also be achieved by surrendering RECs). The scheme covers solar PV, wind, biomass, geothermal and hydroelectricity generators (excluding hydroelectricity generators over 1 MW). RECs can be banked and borrowed across years, with some restrictions.	Commenced 2003, ongoing. If Japan's proposed FIT is adopted in FY2012 as currently intended, the RPS will cease in FY2012. Critics of the scheme claim that it actually impedes the adoption of renewable energy as the standard amount is too low (at about 1% of total generation) and because of the costs created for utility companies in analysing the potential costs of connecting rival renewable energy bids to their grid.	

Policy type	Jurisdiction	Name	Description	Status and duration	References
Energy efficiency regulation	National	Top Runner Program	An energy efficiency program for energy intensive products such as cars and home appliances (currently 23 product categories). Targets are set at the level of the best performing model on the market and manufacturers are directly involved in target setting. METI can disclose the names of companies that fail to meet the targets, as well as issue recommendations, orders and fines. To date, no enforcement actions have been taken as targets have been met or exceeded. This program includes fuel efficiency targets for vehicle manufacturers, expressed in kilometres per litre of fuel (km/L) based on the gross vehicle weight (GVW) category. Manufactures must ensure that in each financial year the average fuel economy of their vehicles in each weight category meets the standard. Flexibilities exist that allow manufacturers to accumulate credits in one weight category for use in another.	The Top Runner Program was Introduced in 1998 and is ongoing. In terms of the status of the vehicle fuel efficiency component of the program, in 2006 the 2015 standards for heavy vehicles above 3.5 tonne were applied. In 2007, the 2015 fuel efficiency targets for light vehicles, including revisions to passenger car and light commercial vehicles standards, and new standards for small buses were applied. Prior to this, 2010 standards were in place.	
	National	Energy Conservation Frontrunner Plan (part of the New National Energy Strategy)	The Energy Conservation Frontrunner Plan has a target of improving energy efficiency by 30% by 2030. It establishes a plan to develop energy conservation technology and the development of 'Top-runner' style standards for energy conservation.	Launched in May 2006 and ongoing.	http://www.meti.go.jp/english/information/downloadfiles/PressRelease/NewEnergyStrategy.pdf
	National	Improvement of energy consumption efficiency of railways	Railway operators are required to complete a 'voluntary action plan' and create and implement a mid- to long-term plan based on the Energy Conservation Act.	Ongoing	Details in Japan's 5th National Communication to the UNFCCC.
Mandatory assessment, audit or investment	National	Mandatory Greenhouse Gas Accounting and Reporting System	Mandatory greenhouse gas emissions reporting to the government required by large emitters. The government publishes the reported data.	Introduced by the revision on Global Warming Countermeasure of 2005. Enforced in April, 2006.	Details provided by Ministry of Environment, Japan.
	National	Law Concerning the Rational Use of Energy (Revised Energy Conservation Act) 2008	Sectoral benchmarks have been established for certain sub-sectors, initially in energy intensive industries. Indicators are established for companies to benchmark their energy efficiency level against others within the same sub-sector, and medium- and long-term targets are set (to be achieved around 2015-2020). Currently, each factory and workplace is required to achieve on average a 1% reduction (or more) in energy intensity annually. The government may take measures against companies they perceive to be making little or no effort, including publishing their name and issuing an order for improvements, enforceable with a fine. In 2005, the Law Concerning the Rational Use of Energy was amended to include new obligations on consigners and carriers (freight and passengers) in the transportation sector.	The Law Concerning the Rational Use of Energy (Energy Conservation Law) was enforced on 1 October 1979, and revised six times until now. The latest revision was promulgated on 30 May 2008 and enforced partly on 1 April 2009 and wholly on 1 April 2010.	http://www.eccj.or.jp/law/e-law.html
	National	Green Management Certification Program	Certifies businesses carrying out a range of environmental efforts covering energy and resource efficiency and pollution mitigation in accordance with the Green Management Promotion Guidelines (developed by the Ministry of Land, Infrastructure and Transport). This program includes freight transport/logistics.	Ongoing	http://www.ecomo.or.jp/english/index.html
Urban or transport planning regulation	National	Eco-Model Cities for a Low-Carbon society	A program established by the Japanese government to create and promote a 'Low-Carbon Society' at a city, national and worldwide level. Each city has an ambitious mid-term and a long-term emissions reduction goal.	6 cities were originally selected in 2008, and 7 more cities were selected in 2009. The project is ongoing.	http://www.jetro.org/content/807/#cities

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	National	Implementation of Intelligent Transport Systems (ITS): central control of traffic signals	Measures intrdouced under the ITS include: Promoting central control of traffic signals; introducing a new traffic control system; implementing model projects concerning the improvement of traffic signal controlling through traffic signal profile control methods; promoting the Environmental Protection Management Systems; developing the Mobile Operation Control Systems for commercial vehicles; prompting traffic information suppliers to provide accurate, appropriate traffic information; operating traffic information examination systems adequately; and operating traffic control information management systems adequately.	Ongoing	http://www.mlit.go.jp/road/ITS/5Ministries/index.html http://www.mlit.go.jp/road/ITS/ Details in Japan's 5th National Communication to the UNFCCC
Other regulation	National	The Law Concerning the Recovery and Destruction of Fluorocarbons	This law aims to limit the emissions of fluorocarbons into the atmosphere by providing guidance for the recovery and destruction of these substances, setting out the responsibilities of relevant operators involved in their use and laying down measures to ensure the recovery and destruction of these substances in specified products and equipment. The law covers Chlorofluorocarbons (CFCs), Hydrochlorofluorocarbons (HCFCs) and Hydrofluorocarbons (HFCs). The regulations include the registration for a permit of operators using and disposing of fluorocarbons, a ban on arbitrary emissions of fluorocarbons and the labelling of end-products that use fluorocarbons.	This legislation was promulgated in June 2001.	http://www.env.go.jp/en/laws/global/ozone1.pdf http://www.meti.go.jp/english/press/data/20100720_01.html
	National	Basic Law for the Promotion of Biomass Utilisation	Introduces targets (set by MAFF) for the proportion of biomass (such as cattle excrement, food waste, wood waste and forestry residue) to be re-utilised by 2020.	A draft law was released by MAFF in August 2010.	
	National	Law on the Promotion of the Use of Non-Fossil Energy Sources and Effective Use of Fossil Energy Source Materials by Energy Suppliers	This law requires gas suppliers to use some portion of biogas and energy suppliers to use some portion of non-fossil energy resources.	Came into force in September 2009.	http://www.meti.go.jp/english/press/data/20090310_01.html
	National	Limit on the maximum speed of large trucks on expressways	Under the Road Trucking Vehicle Act, large trucks are required to have speed limiting devices installed in them, limiting their speed on expressways to 90km/h.		Details in Japan's 5th National Communication to the UNFCCC.
Direct government expenditure					
Government procurement - general	National	Green Purchasing Law and Green Contract Law	Green Purchasing Law: National agencies and public institutions are required to purchase goods and services that meet environmental standards. Green Contract Law: National agencies and public institutions are required to, when contracting, take into consideration greenhouse gas emissions associated with the service.	Green Purchasing Law enacted in 2001. Green Contract Law enacted in 2001.	Details provided by MoE.
Government procurement - carbon offsets	National	Carbon Credit Procurement Program	As of April 2006, the Japanese government will regulate the purchase of up to 100 Mt of carbon dioxide equivalent by 2012 through the Clean Development Mechanism and Joint Implementation.	Scheme started in December 2004 and will continue until at least 2012.	IEA database
Government investment - infrastructure	National	Energy Bank	The Energy Bank invests in the installation of facilities that help reduce CO_2 emissions. The Bank receives a service charge based on the customer's energy consumption, enabling customers to install energy-saving facilities without making an initial investment.	The fund commenced on 1 August 2007.	Japan for sustainability article: http://www.japanfs.org/en/pages/026854.html

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	National	Improving marine transport infrastructure to reduce overland transport distances of international freight	The following objectives have been identified - Developing international marine container terminals in core and hub international ports. - Developing multi-purpose international terminals as logistics centres. - Promoting efforts through the Green Logistics Partnership Conference.	Ongoing	Details in Japan's 5th National Communication to the UNFCCC.
Support for research and development					
R&D - general and demonstration	National	Smart Communities Demonstration project	Demonstration program of 'next-generation energy and social systems' intended to promote the construction of a 'smart grid'. Yokohama City, Toyota City, Kyoto Prefecture (Kansai Science City) and Kitakyushu City have been selected as areas for demonstration projects. According to METI, this scheme has a budget of ¥14.9 billion in fiscal year 2011.	Announced in 2010, with master plans submitted by 4 cities in August.	http://www.meti.go.jp/english/aboutmeti/policy/2011budget.pdf
	National	Ethanol (E3) Production Demonstration	Demonstration program for commercial production of cellulosic ethanol from waste wood biomass. The plant has an annual production capacity of 1400 kilolitres of ethanol fuel from 48 000 tons of construction wood scraps.	Launched 2007	IEA database
	National	Cool Earth Energy Innovative Technology Plan	21 technologies have been selected for priority development and deployment. The program aims to strengthen international cooperation to accelerate innovative technology R&D, through existing international frameworks such as the Carbon Sequestration Leadership Forum (CSLF) and APP on clean coal; GNEP and GIF on nuclear; IPHE on fuel cells; and IEA implementing agreements as well as through exploring new areas for cooperation.	Announced March 2008.	http://www.meti.go.jp/english/newtopics/data/pdf/031320CoolEarth.pdf
	National	Biomass Nippon Strategy	The 'Biomass Nippon' project aims to analyse the local availability of biomass from all existing economic sectors. The program aims to strengthen research capacities (with the establishment of experimental biorefineries), create an institutional structure and carry out policy work to facilitate the use of biomass.	The Biomass Nippon Strategy ran from the base years of 2002 through to 2005. On March 29 2006, the Japanese Ministry of Agriculture, Forestry and Fisheries released a comprehensive evaluation report to examine progress made to date and on March 31 2006, the Japanese Cabinet approved a revision of the Biomass Nippon Strategy, with the view that it is important to promote the use of biomass energy for transportation fuels.	http://www.japanfs.org/en/pages/026352.html
Other					
Labelling scheme	National	Unified Energy Conservation Label	Labels for energy efficiency consumption. The labelling scheme currently applies to air conditioners, TVs, fridges, electric toilet seats and lighting equipment.	Ongoing	http://www.enecho.meti.go.jp/english/toprunnner/11.12english2008_pdf.pdf
	National	Offset Credit Scheme (J-VER)	J-VER is a verification scheme for credits generated through afforestation/reforestation projects. J-VER credits can be purchased by individuals, businesses and local governments. MoE advises that J-VER had a budget of ¥22.2 billion in 2010.	Launched in 2008,ongoing.	Information provided by the Japanese government. MoE information pamphlet: http://www.env.go.jp/en/earth/ets/mkt_mech/fcsb-coc.pdf
	National	Product Carbon Footprint Labelling	A label on products indicating their 'carbon footprint'.	Pilot programme launched in October 2009. Products with label available for sale from February 2010. Ongoing.	http://www.meti.go.jp/english/press/data/20091013_01.html http://www.meti.go.jp/english/press/data/20100114_01.html http://www.cfp-japan.jp

Policy type	Jurisdiction	Name	Description	Status and duration	References
	National	Window Insulation Labelling	The Japanese government has established guidelines for window insulation labelling. Information must be labelled in 4 grades according to: 1) The heat transmission coefficient of windows or window glass 2) The quality and structure of the materials for window sashes.	Introduced December 2008, ongoing.	http://www.meti.go.jp/english/newtopics/data/nBackIssue20071228_03.html
	National	Fuel Efficiency Labelling System	Labels disclosing fuel economy performance, indicating either the status of 'fully compliant' or 'plus 5% / 10% / 20% of the fuel economy standard'.	Started in January 2004 and revised in March 2006. Ongoing.	
	National	Eco Rail Mark	A labelling system for products that use rail freight. A product can carry the label if more than 30% of its transport needs was delivered by rail, while a company can display the label if more than 15% of its freight is transported by rail.	Introduced in 2005, ongoing.	http://www.mlit.go.jp/tetudo/ecorailmark/ecorailmark-english.html
Advertising or educational scheme	National	Cool Biz & Warm Biz	The Cool Biz & Warm Biz campaigns advocate setting air conditioners at 28ºC in summer and at 20ºC in winter in order to reduce greenhouse gases.	Established in 2005, ongoing.	http://www.env.go.jp/earth/info/coolbiz/
	National	Lo-House Promotion	Lo-House is an educational program to demonstrate sustainable housing and lifestyle options to building sector professionals and consumers. Specific measures include the development of a more visible and comprehensible rating and labelling system for housing.	Launched in 2006, ongoing.	
	National	National Promotion for Energy Efficient Home Appliances	The Energy-Efficient Household Appliance Promotion Forum was established with the aim of promoting the use of energy-efficient household appliances through collaboration with concerned parties, including household appliance manufacturers/retailers and consumer groups.	Began in 2007, ongoing.	http://www.meti.go.jp/english/newtopics/data/nBackIssue20071018_03.html
	National	National Promotion of Eco Driving	This initiative to promote 'Eco-driving' includes eco-driving training sessions and is based on the Action Plan for the Diffusion and Promotion of Eco Drive established in 2006.	Launched 2006, ongoing	http://www.env.go.jp/en/headline/headline.php?serial=88 http://www.asiaeec-col.eccj.or.jp/eng/e3105promo_ecod.html
	National	Green Logistics Partnership Conference	The Green Logistics Partnership is an organisation composed of shippers, logistics operators, government and other related member enterprises and organisations, which is managed cooperatively by the MLIT and related organisations, with a view to promoting voluntary efforts of the industrial community towards the greening of logistics systems.	Ongoing	http://www.meti.go.jp/english/press/data/nBackIssue20080904_01.html
	National	Promotion of telework and other transport substitution by ICT	Aims to reduce congestion through encouraging flexible working hours and the use of information and communications technology (ICT).	Action Plan developed in May 2007.	Details in Japan's 5th National Communication to the UNFCCC
Broad target or intergovernmental framework	National	Strategic Energy Plan for Japan	Outlines broad targets for 2030, including to: (a) double the energy self-sufficiency ratio in energy supply and the self-developed fossil fuel supply ratio, and as a result raise the energy independence ratio from the current 38% to about 70% ;(b) raise the zero-emission power source ratio from the current 34% to about 70%; (c) halve CO_2 emissions from the residential sector; (d) maintain and enhance energy efficiency in the industrial sector at the highest level in the world; and (e) maintain or obtain top-class shares of global markets for energy-related products and systems.	Formulated in 2003 and updated every 3 years (updated in 2007 and 2010).	http://www.meti.go.jp/english/press/data/20100618_08.html
	National	Kyoto Target Achievement Plan	Created in order to outline the measures necessary to meet Japan's Kyoto Protocol commitment of 6% emission cuts.	Drafted in April 2005, revised in March 2008.	

Policy type	Jurisdiction	Name	Description	Status and duration	References
	National	Action Plan for Achieving a Low Carbon Society	This plan proposes a long-term global goal of halving total greenhouse gas emissions from current levels by 2050. To achieve this, Japan would set its own target to reduce emissions by 60 to 80 per cent of the current level by 2050. Domestic policies to achieve this goal are set out in the Action Plan and include policies to develop and disseminate innovative 'low-carbon' technologies. The Action Plan also sets out several international/multi-lateral policies such as the 'Cool Earth Partnership' which provides support to developing countries for mitigation, adaptation and access to renewable energy.	Announced June 2008.	
	National	Renewable Energy Target	In 2008, the government raised its target for the proportion of 'new energies' in the total primary energy supply to an upper bound target of 19.1 million kilolitres of oil equivalent and a lower bound of 15.1 million kilolitres of oil equivalent. Specific targets were established for each 'new energy' type. 'New energies' with targets include solar photovoltaic, wind, waste and biomass power and biomass heat utilisation but exclude hydro electric and geothermal.	Implemented 2008 and supersedes previous targets from 1996.	
	National	New National Energy Strategy	A strategy to improve energy security from 2006 to 2030. This incorporates a range of plans, including the Energy Conservation Frontrunner Plan, the Transport Energy for Next Generation Plan and the Nuclear Power Nation Plan.	Commenced in 2006.	http://www.meti.go.jp/english/information/downloadfiles/PressRelease/NewEnergyStrategy.pdf
	National	Japan's Nuclear Energy National Plan (Part of the New National Energy Strategy)	This plan sets out actions to achieve the goals of the Framework for Nuclear Energy Policy: a) continuing to meet at least 30-40% of electricity supply with nuclear, even after 2030; and b) further promoting the nuclear fuel cycle. It also has specific measures to reduce/redistribute investment risks, to share the costs of safety measures, to provide support in research and development and to help finance uranium mine development.	Plan adopted in September 2006.	http://www.enecho.meti.go.jp/english/report/rikkokugaiyou.pdf http://www.meti.go.jp/english/press/data/20100604_02.html http://www.meti.go.jp/english/aboutmeti/policy/2011budget.pdf
	National	New Energy Innovation Plan (Part of the New National Energy Strategy)	Aims to reduce solar energy power generation cost to that of thermal power generation by 2030, and improve self-sufficiency ratios in regions by supporting local production of alternative forms of energy. This plan also promotes the construction of “next-generation parks” to improve the understanding of new energy and the development of revolutionary energy technologies such as next-generation secondary cells.	Commenced in 2006.	http://www.meti.go.jp/english/information/downloadfiles/PressRelease/NewEnergyStrategy.pdf
	National	Transport Energy for the Next Generation Plan (Part of the New National Energy Strategy)	The aim of this plan is to reduce oil dependence to around 80% by 2030. The plan includes: - The establishment of new fuel efficiency standards - Re-examination of upper blending limit regulation of oxygenated compounds - Improving the biomass derived fuel supply infrastructure, and facilitation of the use of diesel cars - Promotion of production and supply of new fuels such as biomass derived fuels and promotion of high-efficiency ethanol production technology and gas to liquid (GTL) technology - Promotion of electric vehicles and fuel cell vehicles - Facilitation of technical development of next generation batteries and fuel cell vehicles, including hydrogen storage technology.	Commenced in 2006.	http://www.meti.go.jp/english/information/downloadfiles/PressRelease/NewEnergyStrategy.pdf
Voluntary agreement	National	Keidanran Voluntary Action Plan (VAP)	Under the Voluntary Action Plan, each industry sets its own emissions or energy reduction target. Industries choose their targets based on one of: 1) CO_2 intensity, 2) absolute CO_2 reduction volume, 3) energy intensity, or 4) total energy consumption. As of March 2010, plans had been established in 113 sectors (51 industry sectors, 41 business sectors, 17 transportation sectors, and 4 energy conversion sectors).	Launched in 1997 by the Federation of Japanese Industries (Nippon Keidanren).	http://www.keidanren.or.jp/english/policy/2010/109.pdf

Policy type	Jurisdiction	Name	Description	Status and duration	References
	National	Basic Program for Housing: Energy Efficiency Standards	The Ministry has set two building efficiency targets for 2015. Firstly, 40 per cent of housing should have energy saving measures, for example double-paned windows (18 per cent as of 2003). Secondly, there is an aim to increase the life span of housing to about 40 years (about 30 years as of 2003).	The Japanese government adopted the "Basic Program for Housing" on 19 September 2006 and plans to improve housing standards over the next 10 years.	http://www.gov-online.go.jp/pdf/hlj_ar/vol_0021e/22-23.pdf
	National	Feasibility Studies on New Mechanisms	Studies into projects involving new policy mechanisms (primarily targeted at cooperation with developing countries to reduce greenhouse gas emissions) with an aim to accumulate knowledge and experience with these mechanisms. Mechanisms include the provision of assistance to developing countries to develop nationally appropriate mitigation actions, sectoral trading mechanisms, and Reduced Emissions for Deforestation and Degradation projects. There was a budget of around ¥60 million in FY2010 for supporting three promising 'Nationally Appropriate Mitigation Actions' projects in Indonesia, Thailand, and Laos.	Launched in 2010, ongoing.	http://gec.jp/gec/jp/Activities/cdm/copmop6/poster2.pdf

New Zealand

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Explicit carbon prices					
Emissions trading scheme - cap and trade	National	New Zealand Emissions Trading Scheme	The New Zealand ETS covers electricity generation, transport fuels and some other sectors (including forestry and industrial processes). In the transition phase (July 2010 to December 2012), one ETS permit (New Zealand Unit) can be surrendered by firms to cover liabilities for two tonnes of CO_2-e emissions, and firms have the option of paying NZ$25 to the Government instead of surrendering a permit. In addition, some international offsets (such as Certified Emissions Reductions certificates) can be used to meet liabilities. From 2013 one permit will be required per tonne of emissions.	Ongoing	http://www.climatechange.govt.nz/emissions trading-scheme http://www.climatechange.govt.nz/emissions trading-scheme/building/
Subsidies and taxes					
Capital subsidy	National	Efficient Lighting Programme	Subsidies for the sale of energy-efficient light bulbs. 2.2 million bulbs were subsidised in 2007-08.	Ongoing	http://www.eeca.govt.nz/eeca-programmes-and-funding/programmes/electricity-efficiency/efficient-lighting
Tax exemption	National	Road User Charges exemption for electric vehicles	Light electric vehicles (up to 3.5 tonnes) are exempt from Road User Charges from October 2009 to July 2013. The exemption is estimated to be worth NZ$400 per exempted vehicle per year, with around 300 vehicles expected to be covered by 2013 (New Zealand Ministry for the Environment estimates).	Ongoing; expires July 2013.	http://www.transport.govt.nz/research/pages /electricvehicles.aspx
	National	Fuel duty exemption for ethanol	Domestic producers and importers of ethanol are exempt from the Accident Compensation Corporation Levy on fuel.	Ongoing	http://www.med.govt.nz/templates/Page___ _12961.aspx
Other subsidy or grant	National	Grants to businesses	Grants for energy audits, design audits, fleet audits and scoping studies; as well as grants for the purchase of energy efficiency or renewable energy technologies. The scheme also includes information provision measures.	Ongoing	http://www.eecabusiness.govt.nz/services-and-funding
	National	Biodiesel Grants Scheme	A subsidy of NZ$0.425/L (2009) for domestic producers of biodiesel with sales of 10 kL per month or more.	Ongoing	http://www.eeca.govt.nz/biodiesel-grants
	National	East Coast Forestry Project	Grants to landowners in specific areas in the East Coast region to plant commercially productive forest on eroding land and land subject to erosion. There is a target of treating 60 000 hectares of eroding hill country. Grants cover the cost of establishing and managing plantations. Current funding is NZ$4.5 million annually.	Ongoing	http://www.maf.govt.nz/forestry/east-coast-forestry
	National	Afforestation Grant Scheme	Competitive grants to landowners for establishing new forests on Kyoto-compliant land (that is, land that was not forested as of 31 December 1989). Half the funding is available to regional councils, and half to private landowners through a tendering process. 70 per cent of funding is allocated to tree species with high sequestration rates. Funding of NZ$7.7 million was allocated for 2010-11.	Ongoing	http://www.maf.govt.nz/climatechange/forestry/initiatives/ags
	National	Permanent Forest Sinks Initiative	A forestry sequestration scheme where participants form an agreement with the Government to plant or manage forests on Kyoto-compliant land (that is, land that was not forested as of 31 December 1989), with a covenant registered against their land title for a minimum of 50 years, under which only limited harvesting is allowed. Landowners then receive tradeable Assigned Amount Units which they can sell on the domestic or international carbon permit markets. The amount of units received equals the increase in CO_2 storage in the forest between 2008 and 2012.	Ongoing	http://www.maf.govt.nz/forestry/pfsi
Fuel or resource tax	National	Fuel duties	New Zealand levies several taxes on petrol (including excise, the Accident Compensation Corporation Levy, the Petroleum Engine Fuels Monitoring Levy and the Local Authority Petroleum Tax) at a total rate of NZ$0.59/L. Excise is levied on LPG at a rate of NZ$0.10/L. There is a small tax on diesel fuel (less than NZ$0.01/L) since diesel use is taxed primarily through a system of 'road user charges' that are based on distance travelled.	Ongoing	http://www.med.govt.nz/templates/Page___ _12961.aspx
Other tax	National	Road User Charges	Vehicles that weigh over 3.5 tonnes, and all vehicles that are diesel powered or powered by a fuel that is not 'taxed at source' must pay Road User Charges (petrol, compressed natural gas and LPG are exempt as these fuels are taxed at source, that is, through fuel excise). These consist of a charge per 1000 km the vehicle travels, with the charge based on on the type and weight of the vehicle. In effect, this means that the use of petrol and diesel in vehicles on public roads is taxed at broadly similar levels (due to higher fuel taxes on petrol).	Ongoing	http://www.nzta.govt.nz/resources/road-user-charges/docs/road-user-charges.pdf

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	National	Common licensing fees	Regular charges on vehicle owners, based on the fuel type and weight (gross mass for freight vehicles) of the vehicle.	Ongoing	http://www.nzta.govt.nz/vehicle/registration-licensing/fees.html
Regulatory instruments					
Energy efficiency regulation	National	Energy Efficient Products Program	This program includes Minimum Energy Performance Standards (MEPS) for several types of appliance (including air conditioners, heat pumps, distribution transformers, domestic fridges and freezers, electric hot water cylinders and fluorescent lamps); compulsory energy efficiency labelling for all whitegoods and heat pumps; and support for the 'ENERGY STAR' voluntary labelling scheme (based on the ENERGY STAR scheme developed by the US Department of Energy). The MEPS and compulsory labelling components are part of the Equipment Energy Efficiency program, which operates across Australia and New Zealand (standards are shared but implemented with separate regulations and penalties).	Ongoing	http://www.eeca.govt.nz/standards-and-ratings/minimum-energy-performance-standards-and-labelling http://energyrating.gov.au/meps1.html
	National	Building Code	Minimum energy efficiency requirements for insulation, heating, ventilation, cooling and lighting in buildings.	Ongoing	http://www.dbh.govt.nz/building-code-compliance-documents http://www.smarterhomes.org.nz/publications/your-guide-to-a-smarter-insulation
Other regulation	National	National Environmental Standard for Landfill Methane	Landfill sites with a design capacity exceeding 1 million tonnes of waste are required to collect and destroy methane emissions.	Ongoing	
Support for research and development					
R&D - general and demonstration	National	Primary Growth Partnership	Agricultural R&D scheme, including some research on emissions mitigation. Funding is at least NZ$500 000 over the lifetime of the program, which must be matched by industry co-investors. The scheme also includes the Centre for Greenhouse Gas Research, with separate funding of NZ$4.85 million each year (fully Government funded), which will focus on reducing methane from ruminants and nitrous oxide and carbon dioxide from soil.	Ongoing	http://www.maf.govt.nz/pgp
	National	Pastoral Greenhouse Gas Research Consortium	Research into the abatement of non-carbon greenhouse gases in agriculture. Industry funding is matched by the Government.	Ongoing	http://www.pggrc.co.nz
	National	New Zealand Agricultural Greenhouse Gas Research Centre	Research centre that focuses on reducing methane and nitrous oxide emissions, as well as soil carbon. Funding is NZ$5 million annually.	Ongoing	http://www.nzagrc.org.nz http://www.maf.govt.nz/environment-natural-resources/climate-change/research-and-funded-projects.aspx
	National	Sustainable Land Management Mitigation and Adaptation to Climate Change	Competitive funding grants for climate change research.	Ongoing	http://www.maf.govt.nz/environment-natural-resources/climate-change/research-and-funded-projects.aspx
R&D - deployment and diffusion	National	Marine Energy Deployment Fund	Four-year NZ$8 million fund to provide grants for deploying pre-commercial devices for wave and tidal energy.	Applications for the last round of grants closed in November 2010; grants are to be provided until 2012.	http://www.eeca.govt.nz/node/1300
	National	Increasing use of wood as a construction material	Funding (NZ$1 million) for research, design competitions, demonstration buildings and information schemes to increase the use of wood as a construction material.	Ongoing	http://www.fida.org.nz/Wood_design
	National	Low Carbon Energy Technologies Fund	Grants for the demonstration of research on 'second generation' biofuels, other low-carbon liquid biofuels, and other low-carbon technologies. A competitive process is used to allocate grants to research bodies. Funding for this scheme is NZ$4 million per year for three years.	Ongoing; funding expires in June 2011.	http://www.iea.org/textbase/pm/?mode=cc&id=3912&action=detail
Other					
Labelling scheme	National	Vehicle Fuel Economy Labelling	Compulsory labelling of vehicles by traders and online vendors, disclosing the fuel efficiency of vehicles. Labels include information about the relative fuel efficiency of a make or model, a star rating (out of six), average fuel consumption (L/100 km), and estimates of annual fuel costs. The scheme applies to all light vehicles whenever information is available. Motorcycles and vehicles over 3.5 tonnes are not included.	Ongoing	http://labelling.fuelsaver.govt.nz
Advertising or educational scheme	National	Safe and Fuel Efficient Driving New Zealand	Driver training course for truck and bus drivers.	Ongoing	

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Broad target or intergovernmental framework	National	Renewable Energy Target	There is a broad target of 90 per cent of electricity in New Zealand to be generated from renewable sources by 2025 (in an average hydrological year), and to be implemented by removing 'unnecessary regulatory barriers' faced by renewable energy generation.	Proposed	http://www.med.govt.nz/upload/73879/Developing%20Our%20Energy%20Potential%20July%202010.pdf
	National	Energy Efficiency Target	Proposed target of 55 petajoules of energy savings from efficiency measures across New Zealand by 2015 (which equates to 9 per cent reduction in energy intensity compared to 2008).	Proposed	http://www.med.govt.nz/upload/73879/Developing%20Our%20Energy%20Potential%20July%202010.pdf
	National	Vehicle Emissions Target	The 2008 Transport Strategy sets a target of 170 g CO_2/km, by 2015, for the combined average of new and used light vehicles.	Ongoing	http://www.transport.govt.nz/ourwork/Documents/NZTS2008.pdf
	National and local	Crown Energy Efficiency Loans Scheme	Funding for central and local government entities, as well as universities and some schools, to implement energy efficiency and renewable energy projects. There were NZ$2 million in loans in 2009-10. Funding for projects is provided through annual rounds.	Ongoing	http://www.eecabusiness.govt.nz/services-and-funding/crown-loans
	National	Sustainable Land Management and Climate Change Plan of Action	A broad program that covers climate change adaptation, emissions reductions, sinks, and business opportunities in the agricultural and forestry sectors. This includes technology transfer (including coordinating activities with industry, information provision, education, and demonstrating new technologies and practices).	Ongoing	http://www.maf.govt.nz/climatechange/slm

South Korea

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Explicit carbon prices					
Emissions trading scheme - cap and trade	National	South Korean Emissions Trading Scheme	The proposed ETS is currently facing pressure for postponement. Details are unclear, however, the target is for a 30 per cent cut in emissions by 2020. The plan is to allocate more than 95 per cent of rights free of charge in the initial stage.	Proposed for 2015. However, legislation has not yet been passed.	http://www.reuters.com/article/2010/11/17/us-carbon-southkorea-idUSTRE6AG1UN20101117 http://www.carbonpositive.net/viewarticle.aspx?articleID=2235
Emissions trading scheme - voluntary	National	Korea Certified Emissions Reductions (KCERs)	A voluntary market for emissions reduction certificates has been in operation since 2005 for firms that reduce emissions by 500 t CO_2 annually. In practice, the government purchases most certificates at around A$4.75/t CO_2.	It has not been decided if KCERs will be taken over by mandatory ETS or connected to the ETS.	Jones and Yoo 2010, Korea's Green Growth Strategy: Mitigating Climate Change and Developing New Growth Engines.
Carbon tax	National	Carbon tax	Proposal to replace a temporary transportation tax with a carbon tax.	Scheduled to commence in 2012.	http://www.koreaherald.com/national/Detail.jsp?newsMLId=20100217000038 http://www.businessgreen.com/bg/news/1803269/south-korea-mulls-carbon-tax
Subsidies and taxes					
Capital subsidy	National	1 million green homes	Subsidies are provided to small-scale renewable generators (including solar PV, solar thermal, wind, geothermal and biomass) with the aim of having 1 million households using renewable energy by 2020.	Ongoing	http://www.kemco.or.kr/new_eng/pg02/pg02040602.asp
	National	Regional deployment subsidy program	Subsidies are provided for building electricity generation infrastructure (100 per cent of costs) and the installation of renewable energy systems (up to 60 per cent of the cost) in some regions.	Commenced in 1996 and ongoing.	http://www.kemco.or.kr/new_eng/pg02/pg02040603.asp
	National	General deployment subsidy program	Capital subsidies are provided for up to 50 per cent of the cost of installing certain renewable energy systems.	Ongoing	http://www.kemco.or.kr/new_eng/pg02/pg02040600.asp
	National	Carbon cashbag scheme	Consumers who purchase high efficiency appliances receive points, which can be used for discounts on public transport, utilities, other appliances or cultural events.	Ongoing	http://www.korea.net/detail.do?guid=28161
Feed-in tariff	National	Feed-in Tariffs	Feed-in tariffs are provided to wide range of new and renewable electricity sources, including wind, solar, biomass, hydro, tidal and fuel cells. The South Korean Government is planning to replace this scheme with a REC scheme in 2012.	Ongoing	
Tax rebate or credit	National	Tax Reduction and Exemption Act	Organisations or individuals may claim 20 per cent of the total investment cost of a renewable installation or energy efficiency investment against income or corporation tax.	Ongoing. KEMCO suggests that this scheme only applies for investments made between 26 September 2008 and 31 December 2009.	http://www.kemco.or.kr/new_eng/pg02/pg02080000.asp http://www.kemco.or.kr/new_eng/pg02/pg02040604.asp
	National	Tax rebates for biodiesel	Domestic producers and importers of biodiesel are entitled to a fuel tax rebate of KRW 528.75/L (in 2010).	It was announced in December 2010 that the tax benefits have been extended to 2011.	http://www.biofuels.apec.org/me_korea.html http://uk.reuters.com/article/2010/12/29/biofuel-korea-idUKTOE6BS01V20101229 http://www.apec-vc.or.kr/?p_name=database&sort2=EG1&gotopage=24&query=view&unique_num=ED2007060137
Tax exemption	National	Light passenger car (less than 1000cc) incentives	Light passenger cars are exempted from the unit consumption tax, education tax, registration tax, acquisition tax, and public debt. Various benefits are also given to the buyer, including a 50 per cent discount on highway tolls, and a 50 per cent discount on fees for public parking lots.	Ongoing	Asia Pacific Energy Research Centre 2010, Compendium of Energy Efficiency Policies of APEC Economies. http://www.un.org/esa/dsd/dsd_aofw_ni/ni_pdfs/NationalReports/korea/Transport.pdf

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	National	Hybrid passenger car incentives	Up to KRW 3.1 million is exempted from the unit consumption tax, education tax, registration tax, and acquisition tax provided that a certain fuel-efficiency standard is met. The tax exemptions on hybrid cars have been implemented on a temporary basis from 1 July 2009 to 31 December 2012.	Ongoing	http://www.un.org/esa/dsd/dsd_aofw_ni/ni_pdfs/NationalReports/korea/Transport.pdf
	National	Tax rebates on interest and dividends on securities from firms with green certificates	Dividends and interest from bonds, deposits and investment funds that invest at least 60 per cent of their capital in green certificates will be exempted from tax (up to a limit). Green certificates are awarded to firms with more than 30 per cent of sales in one of following ten areas: renewable energy, carbon reduction, hydro, green IT, green autos, green housing, high tech materials, clean production, eco-friendly agricultural products, and eco-insurance.	Ongoing	Jones and Yoo 2010, Korea's Green Growth Strategy: Mitigating Climate Change and Developing New Growth Engines. http://www.unepfi.org/fileadmin/events/2010/seoul/Lee.pdf
Preferential, low-interest or guaranteed loan	National	Low interest loans	Long-term low interest loans are available for energy efficiency improvements.	Ongoing	Asia Pacific Energy Research Centre 2010, Compendium of Energy Efficiency Policies of APEC Economies
	National	Loans incentive program	Low interest government loans are provided for up to 90 per cent of the cost of installing or operating renewable energy systems (with the amount reduced to 50 per cent of costs for large corporations).	Ongoing	http://www.kemco.or.kr/new_eng/pg02/pg020406040.asp
	National	Public credit guarantees	Under the five year implementation plan, public credit guarantees will be given to green technology and selected industry sectors.	Ongoing	http://www.bakermckenzie.com/files/News/4769bb3d-b368-4afd-8009-9c540d2628a4/Presentation/NewsAttachment/1e97d42d-04aa-45c1-89a5-5f8ee54d6253/bk_cleanrenewableenergymarketopportunitiespart1_may10.pdf
Fuel or resource tax	National	Fuel excise	Several taxes are levied on petrol and diesel: The Transportation, Energy, Environment Tax; the Education Tax; and the Motor Fuel Tax. The total tax rates are KRW 745.89/L of petrol and KRW 518.18/L of diesel. Other taxes apply to LPG which total KRW 221.06/L.	Ongoing	
Other tax	National	Tax audit exemption	Various businesses, including those operating in the field of alternative energy technology are exempted from tax audits for three years from the first profitable year.	Commenced in September 2008 and ongoing.	http://www.iea.org/textbase/pm/?mode=re&id=4206&action=detail
	National	CO_2 based vehicle tax	Car taxes are likely to be based on fuel efficiency or CO_2 emissions rather than on engine size. Studies and discussions on the car tax reform are still in progress.	Proposed	http://eng.me.go.kr/file.do?method=fileDownloader&attachSeq=1130
	National	Environment Improvement Charge	This charge is levied on diesel vehicles and is based on the engine size, vintage and region. Low emission vehicles are exempted for five years from the first year of registration while vehicles with diesel particulate filters are exempted for three years. Diesel vehicles satisfying EURO-4 standard are exempted for four year and those satisfying EURO-5 standard for five years.	Ongoing since 1992	http://joongangdaily.joins.com/article/view.asp?aid=2902256
Regulatory instruments					
Renewable energy target	National	Public institutions' renewables obligation	New buildings for public institutions (with a floor area exceeding 3000 square metres) must have 5 per cent of total construction costs spent on renewables. Between 2004 and 2009, public institutions spent KRW 484 billion on renewables.	Ongoing	http://www.kemco.or.kr/new_eng/pg02/pg020407022.asp
	National	Public institutions' renewables obligation	All government and state-run enterprise buildings with office space of 1000 square metres or larger must use renewable energy for a minimum of 10 per cent of their energy needs (20 per cent from 2020).	Commences in 2011.	http://www.geni.org/globalenergy/library/technical-articles/generation/policy/bbc-monitoring/south-korea-approves-new-rules/index.shtml
	National	Renewable Portfolio Agreement	Agreement between the government and nine energy related public organisations. The organisations submitted an action plan, and put forward US$0.7 billion for installing 359 MW of renewables from 2006 to 2008.	Will be replaced by the Renewable Portfolio Standard.	http://www.kemco.or.kr/new_eng/pg02/pg020407025.asp http://www.bakermckenzie.com/news/KoreaAustraliaCleanEnergyMarketReport/

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Renewable energy certificate scheme	National	Renewable Portfolio Standard (RPS)	Companies with more than 500 MW of generation capacity must source four per cent of electricity from renewable generation by 2016 and 10 per cent by 2022. Eligible technologies create certificates, and include IGCC (0.25 certificates per MWh); Tidal, waste, Hydro and Wind (1 certificate); and fuel cells (2 certificates). The RPS will replace the voluntary renewable portfolio agreements.	Proposed for 2012.	Jones and Yoo 2010, Korea's Green Growth Strategy: Mitigating Climate Change and Developing New Growth Engines. http://www.energy-daily.com/reports/Cells_Earn_Prominent_Position_Within_South_Korean_Renewable_Portfolio_Standard_Pricing_Mechanism_999.html http://www.usea.org/Publications/Documents/fuel_cells_june_21_2010/USEA_POSCO_0621.pdf http://korea.ahk.de/news/single-view/artikel/renewable-energy-mke-publishes-rps-guidelines/?cHash=a762db1933577afea4f43f8ceeec98b6
Technology standard	National	Phase out of incandescent lights	Korea plans to phase out incandescent light globes by 2013.	Ongoing	IEA 2008, Phase out of incandescent lamps: Implications for international supply and demand for regulatory compliant lamps.
	National	Average energy consumption efficiency system	This system places a standard on the average fuel consumption of each manufacturer's vehicles. From 2012, this standard will be 14.5km/l (1600 cc or less displacement) and 11.2 km/l (greater than 1600cc). There is a proposal for this standard to increase to 17km/l in 2015.	Ongoing	http://www.kemco.or.kr/new_eng/pg02/pg02030200.asp http://www.theicct.org/2010/04/ghg-fe-standards-update/
	National	New Automotive Emissions Standards	Rules supplementing the Air Quality Preservation Act were revised to introduce new automotive emissions standards starting in 2009. The standards will assign emission allowances by manufacturer instead of by car model and fuel type. This means that a manufacturer's vehicle fleet cannot exceed applicable fleet- average emissions standards.	Effective from 2009 onwards.	http://www.iea.org/Textbase/pm/?mode=weo&id=4190&action=detail http://www.un.org/esa/dsd/dsd_aofw_ni/ni_pdfs/NationalReports/korea/Transport.pdf
	National	Inspection regime for heat-using machines and equipment	Boilers, pressure vessels and furnaces must be inspected every one to three years.	Ongoing	http://www.kemco.or.kr/new_eng/pg02/pg02050000.asp
Fuel content mandate	National	Biofuel standard	Minimum 2 per cent biomaterial in diesel fuel by 2012. In 2008, it was reported that the Ministry of Knowledge and Economy (MKE) intended to increase the current biodiesel blend ratio of 1 per cent by 0.5 per cent per annum until it reaches 3 per cent in 2012. However, in December 2010 it was announced that the target would be 2 per cent although the tax break means that this level is already being achieved. There was a trial for E3 bioethanol but deployment has been put on hold.	Ongoing	http://www.biodieselnow.com/biodiesel_outside_of_the_americas1/asia/f/71/t/18204.aspx http://www.jordan-associates.com/Bio-Fuels per cent20Production_Seoul_Korea per cent20- per cent20Republic per cent20of_2-10-2010.pdf http://uk.reuters.com/article/2010/12/29/biofuel-korea-idUKTOE6BS01V20101229
Energy efficiency regulation	National	Minimum energy performance standards	Bans the production of products that fall below required standards. Fines of up to US$16 000 apply. Covers 24 products including fridges, freezers, air conditioners, washing machines, dishwashers, rice cookers, vacuums, fans, light bulbs, boilers and heatpumps.	Ongoing	http://www.kemco.or.kr/new_eng/pg02/pg021002000_2.asp
	National	Energy saving design critera for buildings	Energy saving plans must be submitted for large swimming pools, lodging facilities, hospitals, business facilities, cultural and meeting facilities, schools and apartments with more than 50 units.	Ongoing	http://www.kemco.or.kr/new_eng/pg02/pg020102000.asp
	National	Energy Saving through Partnership (ESP)	Allows companies to share energy saving information through the ESP council. Factories using the more than 20 000 tons of oil equivalent (837 TJ) can participate. Between 2000 and 2007, USD 136 million has been invested in 409 projects through this scheme	Ongoing	http://www.kemco.or.kr/new_eng/pg02/pg021003000.asp http://www.kemco.or.kr/new_eng/pg02/pg021100000.asp
	National	Building Energy Saving Partnership	Voluntary collaborative program for organisations with buildings consuming more than 2000 tonnes of oil equivalent to share information about new technologies or energy management methods.	Ongoing	http://www.kemco.or.kr/new_eng/pg02/pg020104000.asp
	National	Energy efficiency rebates for electricity end use	Rebates for energy efficient lighting, motors, vending machines, inverters, transformers and pumps. These rebates are funded through a 3.7 per cent charge on electricity bills and USD 5 million was spent on these rebates in 2008.		Asia Pacific Energy Research Centre 2010, Compendium of Energy Efficiency Policies of APEC Economies

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	National	Mandatory energy efficiency agreements	The government launched a pilot project of agreements on energy use in 2010. It covers 38 firms, with agreements to reduce energy by 3.7 per cent between 2010 and 2012. There are penalties for non-compliance. These agreements will be replaced by the Greenhouse Gas and Energy Target Management System.	Scheduled to end in 2012.	Jones and Yoo 2010, Korea's Green Growth Strategy: Mitigating Climate Change and Developing New Growth Engines.
	National	Carbon points scheme	Consumers, organisations and companies that reduce their energy use are rewarded with points that can be redeemed for gift vouchers, cash or other incentives.	Ongoing	http://www.korea.net/detail.do?guid=47125 http://www.keco.or.kr/02en/core/climate/index02.jsp
Mandatory assessment, auditing or investment	National	Building certification system	A system to provide information regarding a building's energy consumption and emissions. This system is applicable to apartments with 18 or more units.	Ongoing	http://www.kemco.or.kr/new_eng/pg02/pg02010100.asp
	National	Energy audits	Businesses with annual energy use of more than 2000 tons of oil equivalent must conduct a mandatory energy audit every five years. There are subsidies for small and medium-sized businesses using less than 5000 tons of oil equivalent.	Ongoing	http://www.kemco.or.kr/new_eng/pg02/pg02060000.asp
Urban or transport planning regulation	National	Environment Energy Towns	14 Environment Energy Towns will be built in eight areas by 2020. These towns will make efficient use of waste resources, green power, and biomass.	Ongoing	http://www.unep.org/PDF/PressReleases/201004_UNEP_NATIONAL_STRATEGY.pdf
Other regulation	National	GHG and energy target management scheme	A system of mandatory agreements that is expected to cover 374 470 companies (36 power generators). Companies emitting more than 125 kt CO2 and having an energy consumption of more than 500 terajoules are covered (or 25 kt CO2 and 100 TJ for individual workplaces). This scheme will include an offset system and will cover 60 per cent of national emissions. Companies could face fines of up to KRW 10 million if targets are not met.	Begins in 2012.	http://www.bloomberg.com/news/2010-09-27/south-korea-requires-374-companies-to-set-greenhouse-gas-reduction-targets.html http://www.korea.net/detail.do?guid=50382
Direct government expenditure					
Government procurement - general	National	Procurement guidelines	When purchasing appliances, the Government gives preference to models with grade 1 energy efficiency and less than 1 watt of standby power	Ongoing	http://www.reeep.org/index.php?id=9353&text=policy-db&special=viewitem&cid=151
Government investment - infrastructure	National	Five-Year Green Growth Plan/Green New Deal	Public spending of KRW 107.4 trillion over the period 2009-2013 (2 per cent of GDP) to implement the first Five-Year Green Growth Plan (which has absorbed the Green New Deal stimulus spending of around KRW 50 trillion). Spending items include KRW 22.2 trillion on the Four Major Rivers Restoration project (which will involve the construction of 16 movable dams and reservoirs and 2 small and medium-sized multi-purpose dams) and KRW 25.3 trillion on 'greening the land and water and building the green transport infrastructure'. The total spending includes both mitigation and adaptation measures for climate change.	2009-2013	http://www.korea.net/news.do?mode=detail&thiscode=eng030270&guid=24937 http://www.bakermckenzie.com/files/News/4769bb3d-b368-4afd-8009-9c540d2628a4/Presentation/NewsAttachment/1e97d42d-04aa-45c1-89a5-5f8ee54d6253/bk_cleanrenewableenergymarketopportunitiespart1_may10.pdf http://www.oecd-ilibrary.org/docserver/download/fulltext/5kmbhk4gh1ns.pdf?expires=1297874133&id=0000&accname=guest&checksum=4FC7724B13DD515F7D4FAD6D67AB8D26
	National	Offshore wind farm	The Ministry of Knowledge Economy plans to allocate KRW 9.2 trillion for a 2500 MW wind farm project in collaboration with the private sector. The farm is expected to begin operating in 2013 and will initially generate only 100 MW. By 2016, its total capacity will increase to 1000 MW. It is expected to reach its target capacity by 2019.	Commences in 2013 and fully operational by 2019.	http://www.mke.go.kr/language/eng/news/news_view.jsp?seq=969&srchType=1&srchWord=&tableNm=E_01_01&pageNo=2
	National	Korea High Speed Rail (KHSR) Project	412 kilometres of high speed rail between Seoul, in the north west part of the country, and Busan, a major port city in the south eastern part of the Korean peninsula. Construction of a second high speed line (230.9 kilometres) to replace the conventional line between Osong (in the Chungbuk province) and Mokpo (in the south western part of the country) began in December 2009 and is expected to be operational in 2014.	Seoul to Busan : extension of line to be complete by 2014. Osong to Mokpo : 2006 to 2017.	

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Government investment - environment	National	East Asia Climate Partnership	Partnership aims to develop and advance regional strategies to support clean energy projects. There is a committment of A$220 million to developing countries in East Asia.	Launched in July 2008.	http://www.bakermckenzie.com/files/News/4769bb3d-b368-4afd-8009-9c540d2628a4/Presentation/NewsAttachment/1e97d42d-04aa-45c1-89a5-5f8ee54d6253/bk_cleanrenewableenergymarketopportunitiespart1_may10.pdf
	National	Green SME fund	Establishment of a fund with government seed finance for investing in Green projects in small-medium enterprises.		www.unepfi.org/fileadmin/events/2010/seoul/Lee.pdf
Support for research and development					
R&D - general and demonstration	National	Government R&D investment	Government will invest KRW 1.2 trillion in seven technologies, including energy management systems, electric power IT, energy storage, green vehicles, LEDs, energy efficiency of appliances, and green home appliances.		Asia Pacific Energy Research Centre 2010, Compendium of Energy Efficiency Policies of APEC Economies.
	National	Green car	Government co-contributions in low carbon cars, including KRW 400 billion until 2020 for deveoping hydrogen fuel cell cars and KRW 150 billion annually over five years for fuel efficiency improvements. The Ministry of Knowledge and Economy announced a final plan to develop hybrid and fuel cell-powered vehicles. The initital five year plan began 2006. In 2010, South Korea announced they aim to build 1.2 million electric, plug-in hybrid, and fuel-cell vehicles in the country by 2015.	Expected to end in 2020.	http://www.greengrowth.go.kr/english/en_subpolicy/en_smartcar/en_smartcar.cms http://www.bloomberg.com/news/2010-12-06/south-korea-aims-to-make-1-2-million-hybrid-electric-cars.html
	National	Production of bioethanol from seaweed	The Ministry for Food, Agriculture, Forests and Fisheries (MIFAFF) has announced plans to develop seaweed as a feedstock for bioethanol.The plan's goal is to produce an estimated 12.5 million tons of seaweed on 35,000 hectares by the year 2020.	Ongoing	http://www.jordan-associates.com/Bio-Fuels per cent20Production_Seoul_Korea per cent20- per cent20Republic per cent20of_2-10-2010.pdf
	National	Energy efficiency R&D	R&D program (partially government funded) through the Korean Institute of Energy and Resources Technology Evaluation and Planning. The program aims to support additional energy reductions of 5 per cent. Products covered in the program include boilers, motors, heaters, vents of air conditioning, furnaces, dryers, lighting and home appliances. US$79 million was spent on the program in 2007.	Ongoing	Asia Pacific Energy Research Centre 2010, Compendium of Energy Efficiency Policies of APEC Economies.
	National	Comprehensive R&D Plan on Green Technology	To assist in meeting National Strategy guidelines, this scheme identifies 12 technologies to be prioritised by Korean businesses. The aim is to double R&D spending on these technologies between 2009 and 2012.		http://www.bakermckenzie.com/files/News/4769bb3d-b368-4afd-8009-9c540d2628a4/Presentation/NewsAttachment/1e97d42d-04aa-45c1-89a5-5f8ee54d6253/bk_cleanrenewableenergymarketopportunitiespart1_may10.pdf
	National	Carbon capture and storage investment	Investment of A$110 million in carbon capture and storage between 2010 and 2015, focusing mainly on scoping potential sequestration sites.		http://www.bakermckenzie.com/files/News/4769bb3d-b368-4afd-8009-9c540d2628a4/Presentation/NewsAttachment/1e97d42d-04aa-45c1-89a5-5f8ee54d6253/bk_cleanrenewableenergymarketopportunitiespart1_may10.pdf
	National	Greentech R&D subsidy	Subsidies are available for firms investing in green technology R&D projects. The subsidy rate varies according to the project.	Ongoing	Green Finance: The Korea case.
R&D - deployment and diffusion	National	Smart-grid test bed	Aims to develop the world's largest smart grid on the island of Jeju, consisting of two substations, five distribution lines and serving 6000 households.	Infrastructure being built in 2010-11 and expected to be operational in 2012-2013.	http://www.bakermckenzie.com/news/KoreaAustraliaCleanEnergyMarketReport/
Other					
Information provision or benchmarking	National	Green Logistics Business Partnership Project	Aims to foster cooperation between cargo owners and logistics companies.	Ongoing	http://www.unescap.org/ttdw/common/TPT/egm_eco_efficiency/ms_yeonjoo_min.pdf http://www.meti.go.jp/english/press/data/20100701_02.html

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Labelling scheme	National	Energy efficiency standards and labelling scheme	Mandatory labelling of energy using appliances. Covers 24 products, including fridges and air conditioners.	Ongoing since 1992.	http://www.kemco.or.kr/new_eng/pg02/pg02100101.asp
	National	E-standby program	Mandatory reporting of standby power used by an applicance (fines of up to US$5000 apply for noncompliance) and mandatory labelling of products that do not meet standby standards.	Ongoing since 1999.	http://www.kemco.or.kr/new_eng/pg02/pg021003 00.asp
	National	High efficiency energy using appliance certification program	Identifies products that are above certain standards. These products bear the high-efficient equipment label. This program covers 41 products, including boilers, motors, and inverters.	Ongoing since 1996.	http://www.kemco.or.kr/new_eng/pg02/pg021001 1.asp
	National	Fuel efficiency grade indication system	As of 1 August 2008, South Korean automakers are required to provide carbon dioxide (CO_2) emission level labels for new vehicles manufactured for the domestic market. Labels on new vehicles will indicate fuel efficiency and CO_2 emissions, in kilometres per litre of fuel and CO_2 released per kilometre.	Ongoing	http://www.kemco.or.kr/new_eng/pg02/pg020301 0.asp http://www.un.org/esa/dsd/dsd_aofw_ni/ni_pdfs/NationalReports/korea/Transport.pdf
	National	Carbon footprint labelling	Voluntary scheme that allows products to receive certification of the carbon footprint associated with a product.	Ongoing	http://www.edp.or.kr/carbon/english/system/system_intro.asp
Broad target or intergovernmental framework	National	Emission reduction target	Voluntary emissions reduction target of 30 per cent below business as usual (BAU) by 2020.	Ongoing	http://www.unep.org/PDF/PressReleases/201004_UNEP_NATIONAL_STRATEGY.pdf
	National	Targets	The document 'Road to our Future: Green Growth' sets out a series of targets, including - raising carbon absorbtion by forests to 1.8 billion tonnes of CO2 - decreasing energy intensity to 0.233 toe/USD 1000 - raising renewables use to 6.08 per cent and raising nuclear use to 32 per cent.		Road to our Future: Green Growth
	National	National Strategy and five year implementation plan	As required by the Low Carbon Green Growth Act, this establishes a vision for achieving green growth based on ten policy agenda items split into three objectives: i) mitigation of climate change and energy independence; ii) creation of new engines for economic growth; and iii) improvement in quality of life and enhancement of international standing. The plan also identifies 27 core technologies that are expected to determine future growth for the country. The plan includes a target to increase energy efficiency by 28 per cent in 2020 and 46 per cent in 2030 compared to business as usual levels. This is estimated to result in energy savings of 42 million tonnes of oil equivalent.	Ongoing	http://www.bakermckenzie.com/files/News/4769bb3d-b368-4afd-8009-9c540d2628a4/Presentation/NewsAttachment/1e97d42d-04aa-45c1-89a5-5f8ee54d6253/bk_cleanrenewableenergymarketopportunitiespart1_may10.pdf http://www.unep.org/PDF/PressReleases/201004_UNEP_NATIONAL_STRATEGY.pdf
	National	National Basic Energy Plan	Aims to increase green technology and also establishes specific measures to increase energy efficiency, decrease energy intensity and increase the renewable energy portfolio.	Ongoing	http://www.bakermckenzie.com/files/News/4769bb3d-b368-4afd-8009-9c540d2628a4/Presentation/NewsAttachment/1e97d42d-04aa-45c1-89a5-5f8ee54d6253/bk_cleanrenewableenergymarketopportunitiespart1_may10.pdf
	National	Green Energy Industry Development Strategy	Assists in the implementation of the National Basic Energy Plan by transforming existing industries into low-carbon industries through, for instance, 'green partnerships'.	Ongoing	http://www.bakermckenzie.com/files/News/4769bb3d-b368-4afd-8009-9c540d2628a4/Presentation/NewsAttachment/1e97d42d-04aa-45c1-89a5-5f8ee54d6253/bk_cleanrenewableenergymarketopportunitiespart1_may10.pdf
	National	Third Basic Plan for New Renewable Energy Terchnology Development and Deployment	Sets targets for the use of 'new renewable energy' (wind, bionenergy, waste, geothermal, PV, hydrogen and fuel cells) in primary energy supply. The targets are 4.3 per cent in 2015, 6.1 per cent in 2020 and 11.0 per cent in 2030.	Ongoing	http://www.kemco.or.kr/new_eng/pg02/pg020405 00.asp

Policy type	Jurisdiction	Name	Description	Status and duration	References
	National	The Sustainable Transport & Logistics Act	The Sustainable Transport and Logistics Act: - promotes sustainable transport and logistics policies - requires the government to adopt a sustainability management index and standards - introduces programs to facilitate a shift to sustainable transportation including congestion charging, green logistics certification and shifting freight from road to maritime and rail - promotes non-motorised transport - encourages collaboration with non-governmental organisations - promotes educational measures such as ecodriving.	Commenced in 2010 and ongoing.	http://www.un.org/esa/dsd/dsd_aofw_ni/ni_pdfs/NationalReports/korea/Transport.pdf
	National	Law Concerning the Activation of the Use of Bicycle	This Law was enacted to promote the use of bicycles to alleviate urban traffic problems. This law includes provisions related to expanding the designation and construction of bicycle only lanes, and facilitating the use of land owned by the central and local governments for bicycle keeping facilities.	Ongoing	http://www.glin.gov/view.action?glinID=236602 http://www.ijus-uos.com/ijus/journal/download.php?filename=ch5.pdf
Voluntary agreement	National	Voluntary agreements	Organisations supplying or consuming at least 2 000 tonnes of oil equivalent annually enter into energy reduction and implementation agreements with the Government. In return, financial incentives are offered, such as low interest finance and income tax deductions amounting to 20 per cent of the investment cost.	Ongoing	http://www.kemco.or.kr/new_eng/pg02/pg020901000.asp http://www.oecd-ilibrary.org/docserver/download/fulltext/5kmbhk4gh1ns.pdf?expires=1297874133&id=0000&accname=guest&checksum=4FC7724B13DD515F7D4FAD6D67AB8D26

United Kingdom

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Explicit carbon prices					
Emissions trading scheme - cap and trade	National/EU wide	European Union ETS	European-wide ETS. Most permits are currently issued for free, but as of phase 3, full auctioning will commence for the electricity sector. Other sectors will receive free allowances equal to 80 per cent of a benchmark in 2013 and declining to 30 per cent of a benchmark in 2020 (and estimated to be about 75 per cent of actual emissions in 2013 and 2014). Sectors deemed to be at risk of carbon-leakage will receive allowances of 100 per cent of a benchmark for free. Benchmarks have been determined by reference to the top 10 per cent installations with the lowest carbon intensity in each sector. The overall scheme covers electricity and some industrial facilities, repesenting approximately 40 per cent of EU emissions.	The second phase runs until 2011 and the third phase begins in 2012.	http://ec.europa.eu/clima/policies/ets/index_en.htm http://ec.europa.eu/clima/documentation/ets/docs/proportionate_ia_ per cent20leakage_list16sep.pdf
	National	Carbon Reduction Commitment energy efficiency scheme	The Carbon Reduction Commitment covers energy supplied from electricity, gas, coal, LPG and diesel, that is not covered under an existing climate change measure such as the European Union ETS. Transport is also not covered under the scheme. The scheme covers firms with at least 6000 MWh of electricity use in 2008 and will be a cap and trade scheme, with permits auctioned. In the introductory stage, there will be unlimited allowances sold at a price of £12/t CO_2.	Ongoing. The scheme commenced in April 2010, but full obligations and the purchase of allowances begins in 2011-12.	http://www.decc.gov.uk/assets/decc/Consultations/carbonreductioncommitment/1_20091007084501_e_@@_crcgovresponse.pdf http://www.decc.gov.uk/assets/decc/1_20100120102757_e_@@_crcconsia.pdf http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/crc/crc.aspx
Carbon tax	National	Carbon price floor for electricity generation	From 1 April 2013, a carbon price floor for eletricity generation will be introduced. The carbon price floor will start at around £16/t CO_2 and follow a linear path to £30/t CO_2 in 2020.	Beginning April 2013	http://cdn.hm-treasury.gov.uk/2011budget_complete.pdf
Subsidies and taxes					
Capital subsidy	England	Bio-energy capital grants scheme	Capital subsidies for biomass heat. Maximum funding is £500 000 per project. The scheme covers industrial, commercial and community sectors.	Phase 6 closed for new applications in March 2010. Unclear if there will be further phases.	http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/lc_business/lc_economy/env_trans_fund/bio_grants/bio_grants.aspx
	England	Offshore wind capital grants scheme	Capital subsidies for the construction of offshore wind farms, set at 40 per cent of costs in excess of the cost of building a conventional power station.	Ongoing	http://decc.gov.uk/en/content/cms/what_we_do/lc_uk/lc_business/lc_economy/env_trans_fund/wind_grants/wind_grants.aspx
	England	Energy crops scheme	Farmers receive subsidies of up to 50 per cent of establishment costs for plantations of short rotation coppice and miscanthus. Crops can be used for heat, combined heat and power or electricity.	Ongoing	http://www.naturalengland.org.uk/ourwork/farming/funding/ecs/default.aspx
	Scotland, England and Wales	Boiler scrappage scheme	Offers households with inefficient boilers £400 towards the cost of a new energy efficient boiler. £54 million (133 976 vouchers) was allocated to the scheme. The re-opened Scotland scheme has a further £1 million of funding. As at 9 August 2010, 118 801 boilers had been installed under the scheme.	Closed to new entrants (March 2010) with requirement for vouchers to be used within 3 months. However, the 'Scotland Boiler Scrappage Scheme' extending the nationwide scheme has recently re-opened.	http://www.energysavingtrust.org.uk/scotland/Scotland-Welcome-page/At-Home/Energy/Scottish-Boiler-Scrappage-Scheme http://www.energysavingtrust.org.uk/Home-improvements-and-products/Heating-and-hot-water/Boiler-Scrappage-Scheme http://www.energysavingtrust.org.uk/scotland/Scotland-Welcome-page/At-Home/Home-Energy-Scotland/Scottish-Boiler-Scrappage-Scheme
	Scotland	Private sector landlord boiler scrappage scheme	Landlords can receive up to £400 towards replacing inefficient boilers in any of their rented properties. Funding for this scheme is £1 million from the Scottish Government.	Closed on 25 March 2011 in Scotland.	http://www.energysavingtrust.org.uk/scotland/Scotland-Welcome-page/Business-and-Public-Sector-in-Scotland/Private-Sector-Landlords/Private-Sector-Landlords-Boiler-Scrappage-Scheme
	National	Low carbon infrastructure fund	Fund designed to support low carbon community heating schemes. Funds of £25 million plus an additional £4.8 million from the Department for Communities and Local Government are available.	All the funding has been committed and no further funding is available at present for District heating schemes.	http://www.homesandcommunities.co.uk/low-carbon-infrastructure
	National	Subsidies for low carbon cars	A 25 per cent subsidy (up to £5000) for the purchase of low carbon vehicles.	Ongoing, but only the first year of funding is guaranteed.	http://www.dft.gov.uk/pgr/sustainable/olev/ http://nds.coi.gov.uk/content/detail.aspx?NewsAreaId=2&ReleaseID=415500&SubjectId=2

Policy type	Jurisdiction	Name	Description	Status and duration	References
	Scotland	Community And Renewable Energy Scheme	Offers subsidies to community organisations (such as schools) in Scotland to assist with the installation of renewable energy technologies. Grants can be used for feasability or scoping studies, capacity building (maximum of £15 000) or capital costs (maximum of £150 000). The grant amount is determined on a case by case basis. Approximately £9.5 million was allocated between April 2009 and September 2010.	Ongoing	http://www.communityenergyscotland.org.uk/cares.asp http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Energy-sources/19185/Communities/CRES http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Energy-sources/19185/Communities/CARESREPT
	England	Warm front	A subsidy of up to £3500 for insulation and energy efficient heating improvements, or up to £6000 where oil, low carbon or renewable energy heating is recommended. Available for people receiving government benefits.	Ongoing	http://www.warmfront.co.uk/index.htm http://www.decc.gov.uk/assets/decc/Consultations/warm-front-eligibility/1029-consultation-warm-front-eligibility.pdf http://www.decc.gov.uk/assets/decc/Consultations/warm-front-eligibility/1030-ia-warm-front-eligibility.pdf
	Northern Ireland	Warm homes scheme	This scheme provides insulation measures costing up to £850 for people receiving government benefits. The scheme also provides energy efficient oil or gas heating where required, with a maximum value of £4300.	Ongoing	http://www.nidirect.gov.uk/index/information-and-services/money-tax-and-benefits/benefits-and-financial-support/on-a-low-income-1/warm-homes-scheme.htm
	Scotland	Energy assistance package	Installation of insulation or energy efficent heating for people receiving government benefits.	Ongoing	http://www.scotland.gov.uk/Topics/Built-Environment/Housing/access/FP/eap
	Wales	Home Energy Efficiency Scheme (HEES)	Provides grants of up to £3600 for heating and insulation for selected low income households (£5000 where oil central heating is required). As of 2009, £100 million has been spent on this scheme.	Ended 31 March 2011	http://www.heeswales.co.uk/
	Wales	Nest	New scheme replacing the HEES. Offers a range of energy efficiency improvements for low income households	Begun April 2011.	http://www.nestwales.org.uk
	Scotland	Home insulation scheme	The home insulation scheme conducts energy checks and delivers discounted or free insulation to eligible households in Scotland. Funding for the scheme was £15 million in 2009-10 and will increase to £25 million in 2010-11.	Ongoing	http://www.energysavingtrust.org.uk/scotland/Scotland-Welcome-page/At-Home/Home-Insulation-Scheme/What-is-the-Home-Insulation-Scheme http://www.scotland.gov.uk/News/Releases/2010/02/10123022
	Wales	Arbed	This scheme is targeted at energy efficiency and renewable energy in low income areas. £30 million was spent during phase one of the scheme (May 2010 to March 2011).	Ongoing	http://wales.gov.uk/topics/environmentcountryside/energy/efficiency/arbed/;jsessionid=STLfMr7FrQGCqh8Gh1Y1nbwTXnD9nwch2byhpQjp2LHLG6ZVNhRQ!320120316?lang=en
	England	Green bus fund	A fund (£45 million) supporting bus companies in England when purchasing low carbon buses.	Round 2 closed October 2010.	http://www.dft.gov.uk/pgr/regional/buses/greenbusfund/
	Scotland	Scottish Green Bus Fund	A green bus fund to help with the purchase costs of low carbon buses in Scotland.		http://www.scotland.gov.uk/Topics/Transport/BusandTaxi/scottishgreenbusfund
	Scotland	Scottish Clean Energy Demonstration Scheme	A grant scheme to assist the demonstration and development of energy efficiency and renewable energy technology. Grants may be awarded to eligible firms to cover capital and revenue costs and the grant limit is £80 000 per project. For projects costing up to £100 000, the grant is 45 per cent of eligible costs. For projects above £100 000, the grant is 45 per cent of the first £100 000, and 35 per cent of costs between £100 000 and £200 000	Ongoing	http://www.energysavingtrust.org.uk/Global-Data/Funding-Information/Scottish-Clean-Energy-Demonstration-Scheme
	Scotland	Energy Efficiency Design Awards	A £1 million fund aimed at communities and housing providers, focussing on energy efficiency in hard to treat housing. The maximum award is £250 000.	Ongoing	http://www.energysavingtrust.org.uk/scotland/Scotland-Welcome-page/Business-and-Public-Sector-in-Scotland/Grants-loans-awards/Energy-Efficiency-Design-Awards

Policy type	Jurisdiction	Name	Description	Status and duration	References
Feed-in tariff	National	Feed-in Tariffs (FITs)	Feed-in tariffs apply to small scale renewable generation of less than 5 MW capacity. The scheme covers electricity generated from wind, solar photovoltaic, hydro, anaerobic digestion, and domestic scale micro-CHP (capacity of 2kW or less). The tariff for each generation type depends on the capacity of individual plants. Small generators that are already part of the Renewable Obligation Scheme are generally not covered, but can elect to receive FITs rather than Renewable Obligation Certificates, at a rate of £0.09 per kWh. In many cases, if a generator has received a subsidy from another scheme, they will not be eligible for FITs. Eligible generators receive a generation tariff (with the rate dependent on the technology) and a set export tariff for energy exported to the grid.	Commenced April 2010.	http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/feedin_tariff/feedin_tariff.aspx http://www.decc.gov.uk/assets/decc/Consultations/Renewable per cent20Electricity per cent20Financial per cent20Incentives/1_20100204103559_e_@@_FITsImpactAssessmentaccompanyingGovernmentResponse.pdf
	National	Feed-in-tariffs for all renewables	Under the Electricity Market Reform process, DECC is currently consulting on a feed-in-tariff regime for all renewable generation. The preferred model is a 'Contract for Difference' model whereby generators receive the difference between the electricity price and the agreed tariff (and pay back revenues if the electricity price exceeds the agreed tariff). There is also consultation on a premium FIT model where there is a fixed premium on the electricity price provided.	Proposed	
Tax rebate or credit	National	Vehicle excise duty	The tax rate on vehicles in the United Kingdom differs depending on the emissions intensity of the vehicle. This can range from £0 (for cars below 100g CO_2/km to £435 a year for cars over 255g CO_2/km. There are also reduced rates for cars on alternative fuels. This applies for cars first registered in 2001 onwards.	Ongoing	http://www.direct.gov.uk/en/Motoring/OwningAVehicle/HowToTaxYourVehicle/DG_172916 http://www.dft.gov.uk/rmd/project.asp?intProjectID=11615
	National	Reduced VAT for energy saving materials and microgeneration	Reduced VAT (5 per cent instead of 20 per cent) on materials for insulation, hot water and central heating controls, and for renewable energy microgeneration. A reduced rate also applies to other items such as fuel and power for domestic use (regardless of carbon content).	Ongoing	http://webarchive.nationalarchives.gov.uk/ http://www.hm-treasury.gov.uk/budget/budget_2000/press_notices/bud_bud00_pressenergy.cfm http://www.hmrc.gov.uk/vat/forms-rates/rates/goods-services.htm http://customs.hmrc.gov.uk/channelsPortalWebApp/channelsPortalWebApp.portal?_nfpb=true&_pageLabel=pageVAT_ShowContent&id=HMCE_CL_000510&propertyType=document
	National	Landlord Energy Saving Allowance	Allows landlords to claim a tax deduction for the installation of wall, loft, floor, and hot water insulation as well as draught proofing. The deduction can be up to £1500 per year.	Ongoing	http://www.direct.gov.uk/en/HomeAndCommunity/Privaterenting/RentingOutYourProperty/DG_175186 http://www.propertylettings.org/landlord per centE2 per cent80 per cent99s-energy-saving-allowance-lesa-uk-86.html http://www.hmrc.gov.uk/ria/8-landlords-energy-saving-allow.pdf
	National	Enhanced Capital Allowances	While most capital expenditures in the United Kingdom are written off on a reducing balance basis, investments under the Enhanced Capital Allowances can be written off at 100 per cent in the initial year. Eligible investments include energy saving plants and machinery, low carbon cars, natural gas and hydrogen refuelling infrastructure, and water conservation plants and machinery.	Ongoing	http://www.eca.gov.uk/ http://www.hmrc.gov.uk/research/report-54.pdf
	Northern Ireland	Low carbon homes scheme	Provides rate exemptions for low carbon homes (for 2 years) and zero carbon homes (for 5 years) for homes completed after April 2010.	Ends March 2013 for low-carbon homes and March 2016 for zero carbon homes.	http://www.nidirect.gov.uk/lps_fact_sheet_-_low_carbon_homes_sep10.pdf
	National	Zero-carbon homes land tax exemption	Complete exemption from stamp duty at the first point of sale for zero-carbon houses costing less than £500 000 and a £15 000 reduction on homes worth more than £500 000.	Ends September 2012	http://www.hmrc.gov.uk/ria/9-zero-carbon-homes.pdf
Preferential, low-interest or guaranteed loan	National	Energy efficency loans for small and medium enterprises	Zero interest loans of up to £100 000 are available for small-medium enterprises to invest in energy efficiency projects. A loan of £1000 can be given for every 2.5 tonne of CO_2 abated. Since 2003, £150 million has been spent on interest free loans.	Ongoing	http://www.carbontrust.co.uk/cut-carbon-reduce-costs/products-services/business-loans/pages/loans.aspx http://www.carbontrust.co.uk/Publications/pages/publicationdetail.aspx?id=CTC778
	Scotland	Energy saving Scotland - small business loans	Zero interest loans of up to £100 000 are available for small-medium enterprises to invest in energy efficiency projects in Scotland.	Ongoing	http://www.energysavingtrust.org.uk/scotland/Scotland-Welcome-page/Business-and-Public-Sector-in-Scotland/Grants-loans-awards/Small-business-loans

Policy type	Jurisdiction	Name	Description	Status and duration	References
	National	Salix	Salix receives funding from the Carbon Trust and assists public sector bodies with energy efficiency improvements. The first option offered by Salix is a recycling fund (£40 million), where a body is given funding for certain projects and can then use the energy savings from these projects to undertake more projects. The money is returned when no more projects are available. The second option is the provision of loans which are repaid from energy savings. The loans program was allocated £63 million of interest free loans in 2009-10.	Ongoing. Recycling fund now closed.	http://www.salixfinance.co.uk/about_us.html
	Scotland	Central energy efficiency fund	Provides low interest loans to the public sector in Scotland to assist with energy efficiency and small-scale renewable energy investment. Savings from energy efficiency measures are then used to invest in further energy efficiency measures or improve frontline services. This fund was allocated £20 million.	Ongoing	http://www.energy-efficiency.org/ceef/21.html http://www.scotland.gov.uk/Resource/Doc/174006/0048526.pdf
	National	Green Deal	The Green Deal is a proposed financing agreement for household energy efficiency measures. Energy efficiency measures are installed in houses and are then paid for through energy bills. The energy bill payment will not exceed the projected savings from the energy efficiency measure. The finance period can last up to 25 years, and will pass on to the new owner of the home should the existing owner move.	Proposed to commence in the second half of 2012.	http://www.decc.gov.uk/en/content/cms/legislation/energy_bill/energy_bill.aspx http://www.decc.gov.uk/assets/decc/legislation/energybill/1002-energy-bill-2011-ia-green-deal.pdf
Other subsidy or grant	Great Britain	Renewable Heat Incentive	The Renewable Heat Incentive will provide tariff support for those who install renewable heating. This scheme will provide payments based on the annual amount of heat output, over a number of years. Payments will be made annually for installations below 45 kW and quarterly for installations above 45 kW, with tariffs intended to deliver a 12 per cent rate of return on capital cost (6 per cent on solar thermal).	Proposed and expected to commence in June 2011. There is a commitment to remain open to new plants until 2020.	http://decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/policy/renewable_heat/incentive/incentive.aspx http://www.decc.gov.uk/assets/decc/Consultations/RHI/1_20100204094844_e_@@_ConsultationonRenewableHeatIncentive.pdf http://www.decc.gov.uk/assets/decc/Consultations/RHI/1_20100201105915_e_@@_ImpactAssessmentforRHIConsultation.pdf
	National	Mode Shift Revenue Support and Waterborne Freight Grant scheme. Formerly known as Rail Environmental benefits Procurement Scheme	Assists companies with the additional operating costs (where applicable) associated with running rail and water freight transport instead of road transport.	Ongoing	http://www.freightbestpractice.org.uk/products/3705_5349_the-mode-shift-revenue-support-scheme.aspx
Fuel or resource tax	National	Differential fuel excise	While differential fuel excise for most biofuels has been phased out, fuel created from used cooking oil will still attract a lower rate until 2012.	Ongoing, expires in 2012.	
	National	Fuel excise	Excise is applied to all road transport fuels in the United Kingdom. In 2010 the rates averaged £0.57/L of petrol or diesel and £0.17/L of LPG. The United Kingdom has justified increases in rates of fuel excise as an emissions reduction measure.	Ongoing	HM Revenue & Customs
	National	Climate Change Levy (CCL)	The non domestic use of fossil fuels and electricity is taxed (excluding oil, heat, steam and gaseous transport fuels). In 2010 the rate was £0.00470/kWh for electricity with fossil fuels taxed at varying rates. Renewable electricity (with the exception of large scale hydro) and 'good quality' combined heat and power systems are exempt from the tax.	Ongoing. Reform proposals are expected to be introduced in April 2013.	http://customs.hmrc.gov.uk/channelsPortalWebApp/channelsPortalWebApp.portal?_nfpb=true&_pageLabel=pageExcise_InfoGuides&propertyType=document&id=HMCE_CL_001174 http://www.decc.gov.uk/en/content/cms/what_we_do/change_energy/tackling_clima/ccas/cc_levy/cc_levy.aspx http://www.hm-treasury.gov.uk/d/consult_carbon_price_support_condoc.pdf
Other tax	National	Landfill tax	Tax levied on all goods which give off greenhouse gases whilst in a landfill. The tax is £48/t for active waste and rises by £8/t per year until at least 2014/15. There is a lower rate for non-active material of £2.50/t.	Ongoing	http://www.defra.gov.uk/environment/waste/strategy/factsheets/landfilltax.htm http://www.parliament.uk/briefingpapers/commons/lib/research/briefings/snbt-01963.pdf
	National	Air passenger duty	The air passenger duty is levied on flights departing the United Kingdom, with the rate depending on the distance of the flight. New rates were introduced in November 2009 using four standard distance bands, with air passenger duty increasing with distance.	Ongoing	http://customs.hmrc.gov.uk/channelsPortalWebApp/downloadFile?contentID=HMCE_CL_000505 http://www.hmrc.gov.uk/ria/apd-reform-ia.pdf

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Regulatory instruments					
Renewable energy target	National (EU directive)	Renewable Energy Directive 2009 (Transport target)	Directive 2009/28/EC of the European Parliament and of the council requires that 10 per cent of energy used in transport should be renewable energy by 2020.	Ongoing	http://www.decc.gov.uk/assets/decc/what per cent20we per cent20do/uk per cent20energy per cent20supply/energy per cent20mix/renewable per cent20energy/renewable per cent20energy per cent20strategy/1_20090715120318_e_@@_ukrenewableenergystrategy2009iaforthetransportsectorurn09d684.pdf http://www.r-e-a.net/document-library/thirdparty/rea-and-fqd-documents/REDDoc_090605_Directive_200928EC_OJ.pdf
Renewable energy certificate scheme	England, Wales and Scotland (Northern Ireland has a similar scheme in place, but with different targets).	Renewables Obligation	Electricity retailers are required to purchase Renewable Obligation Certificates created by renewable generators, or alternatively pay a 'fine'. Renewable generators receive different numbers of certificates per MWh depending on the technology used.	Ongoing, although the recently announced 'Electricity Market Reform' consultation document envisages the replacement of Renewables Obligation with Feed-in tariffs, with accreditation under the Renewables Obligation continuing until 2017.	http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/policy/renew_obs/renew_obs.aspx http://www.detini.gov.uk/deti-energy-index/deti-energy-sustainable/northern_ireland_renewables_obligation_.htm http://www.decc.gov.uk/assets/decc/Consultations/emr/1041-electricity-market-reform-condoc.pdf
Technology standard	National	Carbon Capture and Storage readiness	Any new coal fired power station with a capacity of over 300 MW must be built with no forseeable barriers to carbon capture and storage.	Ongoing	
	National (EU directive)	Eco design for energy using products	Standards for energy use in the manufacture, use and disposal of certain products, such as hot water boilers, fridges and freezers, and lighting.	Ongoing	http://www.defra.gov.uk/environment/business/products/energy/documents/energy-products-regs-guide.pdf http://efficient-products.defra.gov.uk/cms/eup/
	National (EU directive)	Phase out of incandescent light bulbs (EU wide)	The European Union is aiming to phase out the use of incandescent light bulbs by September 2012.	Steady phasing out: September 2009, 100w phased out; September 2010, 75w phased out; September 2011, 60w phased out; and September 2012 all remaining bulbs.	http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/09/368&format=HTML&aged=0&language=EN http://www.parliament.uk/briefingpapers/commons/lib/research/briefings/snsc-04958.pdf http://www.defra.gov.uk/environment/business/products/roadmaps/lightbulbs.htm
	National (EU directive)	Vehicle emissions standards (passenger cars)	Directive EC Regulation No. 443/2009 2009/443/EC requires that new passenger cars comply to emissions standards of 120 g CO_2/km by 2012. This consists of a reduction to 130 g CO_2/km from engine technology plus 10 g CO_2/km from improved vehicle efficiency features (for example, air conditioning). The policy covers the average fleet of each car manufacturer (that is, all models produced) and is being phased in until 2015. A further "long-term target" of 95g CO_2/km by 2020 is included in the regulation.	Ongoing	http://ec.europa.eu/reducing_co2_emissions_from_cars/index_en.htm http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0001:0015:EN:PDF http://webarchive.nationalarchives.gov.uk/+/http://www.dft.gov.uk/consultations/closed/co2emissions/fia.pdf
	National (proposed EU directive)	Vehicle emissions standards (vans)	Proposed EC Regulation sets an EU-wide target for new van CO_2 emissions of 175 g CO_2/km by 2016 and 135g CO_2/km by 2020	Proposed	http://www.dft.gov.uk/consultations/closed/2010-19/ia.pdf
	National (EU directive)	Tyre pressure monitoring systems, gear shift indicators and low rolling resistance tyres	EC Regulation No. 661/2009 requires, amongst other things, the introduction of tyre pressure monitoring systems, gear shift indicators and the use of low rolling resistance tyres.	Ongoing.	http://ec.europa.eu/clima/documentation/transport/vehicles/docs/sec_2007_60_ia.pdf

Policy type	Jurisdiction	Name	Description	Status and duration	References
	National (EU directive)	Vehicle air conditioning system regulations	Directive 2006/40/EC to control the use of fluorinated greenhouse gases in air conditioning systems in motor vehicles. The directive bans air conditioning systems that use greenhouse gases with a global warming potential greater than 150, unless the rate of leakage is within permissible limits.	A total ban on air conditioning systems that use greenhouse gases with a global warming potential greater than 150 will come into effect for type-approval of all new vehicles types from 1 January 2011, and the sale of all new vehicles from 1 January 2017.	http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_161/l_16120060614en00120018.pdf
	National	Emissions performance standard	Government currently consulting on introducing an emissions performance standard on new coal plants (with exemptions for plants included in the CCS Demonstration programme).	Proposed	http://www.decc.gov.uk/en/content/cms/consultations/emr/emr.aspx
Fuel content mandate	National	Renewable Transport Fuels Obligation	The Renewable Transport Fuels Obligation requires domestic refineries and importers of refined conventional fuels to ensure that a specified percentage of road transport fuels that they supply are biofuel. The target for fiscal year 2009 was 3.25 per cent by volume of fuel. This has been raised to 3.5 per cent in fiscal year 2010. The scheme includes tradeable certificates and suppliers could 'buy out' of their obligation for £0.15/L in 2009.	Ongoing	http://www.renewablefuelsagency.gov.uk/
	National (EU directive)	Fuel Quality Directive	Directive 2009/30/EC of the European Parliament and of the council states that there should be a minimum reduction in lifecycle greenhouse gas emissions from road transport of 6 per cent by 31 December 2020. The Directive identifies an additional 4 per cent reduction, where 2 per cent is from Carbon Capture & Storage and the supply of electricity for electric vehicle use, and 2 per cent is through the purchase of Kyoto Clean Development Mechanism credits.	Ongoing	http://www.r-e-a.net/document-library/thirdparty/rea-and-fqd-documents/FQD_090605_Directive_200930EC_OJ.pdf http://www.decc.gov.uk/assets/decc/what per cent20we per cent20do/uk per cent20energy per cent20supply/energy per cent20mix/renewable per cent20energy/renewable per cent20energy per cent20strategy/1_20090715120318_e_@@_ukrenewableenergystrategy2009iaforthetransportsectorurn09d684.pdf http://www.renewablefuelsagency.gov.uk/
Energy efficiency regulation	National	Building regulations	Requires that buildings constructed in 2010 be 25 per cent more energy efficient than a similar dweling built in 2006 and buildings constructed in 2013 be 44 per cent more efficient. There is government commitment for all new homes to be zero-carbon by 2016.	Ongoing	http://www.communities.gov.uk/planningandbuilding/buildingregulations/ http://www.legislation.gov.uk/uksi/2010/675/pdfs/uksi_20100675_en.pdf http://www.communities.gov.uk/documents/planningandbuilding/pdf/1418640.pdf
	National	Integrated pollution prevention and control	Certain industries must have a permit that limits emissions based on the application of best available techniques. Pollutants other than greenhouse gases are also included. Greenhouse gases are not required to be limited where they are subject to the emissions trading scheme, unless they may cause local pollution.	Ongoing	http://www.defra.gov.uk/environment/quality/pollution/ppc/background/index.htm http://ww2.defra.gov.uk/environment/quality/industrial/ http://www.defra.gov.uk/environment/quality/pollution/ppc/background/documents/ppcregs-review.pdf
	National	Carbon Emissions Reduction Target	The Carbon Emissions Reduction Target requires that all energy suppliers with over 50 000 customers facilitate the application of energy efficiency measures in households. The scheme has recently been extended to run until December 2012, with a target of 293 Mt of lifetime abatement. This represents an increase of 108 Mt on the March 2011 target. At least two-thirds of this increase must be met by insulation measures and non-compliance may result in fines.	Runs until December 2012 (when it will be replaced by 'the energy company obligation' and the Green Deal).	http://www.decc.gov.uk/en/content/cms/what_we_do/consumers/saving_energy/cert/cert.aspx http://www.publications.parliament.uk/pa/cm200809/cmselect/cmenvfru/37/3706.htm http://www.decc.gov.uk/assets/decc/Consultations/certextension/121-iacertextension.pdf

Policy type	Jurisdiction	Name	Description	Status and duration	References
	National	Energy Company Obligation (ECO)	The Energy Company Obligation will replace the Carbon Emissions Reduction Target, and run alongside the Green Deal. Details are still unclear, but it is likely that the scheme will target poorer households who cannot improve their energy efficiency without support.	Proposed to commence in 2012 when the Carbon Emissions Reduction Target is due to end.	http://www.decc.gov.uk/en/content/cms/legislation/energy_bill/energy_bill.aspx http://www.decc.gov.uk/assets/decc/legislation/energybill/1002-energy-bill-2011-ia-green-deal.pdf http://www.decc.gov.uk/assets/decc/legislation/energybill/540-energy-security-bill-brief-energy-company.pdf
	Northern Ireland	Northern Ireland Sustainable Energy Programme	Money collected from a levy placed on electricity customers is used to fund energy efficiency projects via a tender process. One prerequisite to using the funds is that the scheme must lead to economic benefits to Northern Ireland as well as financial benefits to the customer.	Bids opened in 2009 for funding to begin in April 2010. The scheme is designed to run for three years before being reviewed.	http://www.uregni.gov.uk/uploads/publications/Appendix_1_NISEP_FD_consultation_July_09.pdf
	National	Community Energy Saving Programme	This program requires gas/electricity suppliers and generators with at least 50 000 customers to deliver energy saving measures in specific low income areas. The obligation is assigned to generators/retailers based on their share of generation/customers. The obligation can be traded between companies. Actions counted under the Carbon Emissions Reduction Target will not be counted under the Community Energy Saving Programme.	Runs until December 2012.	http://www.ofgem.gov.uk/Sustainability/Environment/EnergyEff/cesp/Pages/cesp.aspx http://www.decc.gov.uk/assets/decc/Consultations/CESP/1_20090710121840_e_@@_CESPIA.pdf
Mandatory assessment, auditing or investment	Great Britain	Smart meters	Roll out of smart electricity meters to all domestic homes in Great Britain.	Ongoing	http://www.decc.gov.uk/assets/decc/legislation/energybill/548-energy-security-bill-brief-smart-meters.pdf http://www.decc.gov.uk/assets/decc/Consultations/Smart per cent20Metering per cent20for per cent20Electricity per cent20and per cent20Gas/1_20091202164552_e_@@_smartmeterdomesticia.pdf
Other regulation	National	Fluorinated greenhouse gas regulations	Legal and qualification requirements in five sectors (refrigeration, air conditioning, heat pumps, fire protection, mobile air conditioning, high voltage switchgear and solvents) relating to leakage checks, recovery, reporting, labelling, prohibition of use and market restrictions.	Ongoing	http://ww2.defra.gov.uk/environment/quality/air/fgas/ http://www.defra.gov.uk/environment/quality/air/fgas/documents/impact-assessment.pdf
	England	Landfill and Allowances Trading Scheme	The Landfill and Allowances Trading Scheme sets a limit on the amount of waste each disposal authority in England can send to landfill. This limit can be traded between authorities	Ongoing	http://www.defra.gov.uk/environment/waste/localauth/lats/
Direct government expenditure					
Government procurement - general	National	Low carbon vehicle procurement programme	A £20 million fund to assist the public sector with the additional costs associated with procuring low carbon vehicles.	Phase 1 closed. Subsequent phases depend on the success of the initial phase.	http://www.dft.gov.uk/pgr/scienceresearch/technology/lowcarbonvehicleprocurementprog http://www.lcvpp.org.uk/information/programme-objectives
	National	Government transport procurement standards	List of criteria for new government vehicles. For example, new passenger cars must not exceed an average of 130g CO_2/km. This program also includes criteria for vans, buses and waste collection services.	Ongoing	http://www.defra.gov.uk/sustainable/government/advice/public/buying/products/transport/spec/transport.htm
	National	Government buying standards	List of standards the government must follow when procuring a range of products. In relation to products using energy, these standards follow the energy using products scheme.	Ongoing	http://www.defra.gov.uk/sustainable/government/advice/public/buying/index.htm
Government investment - infrastructure	National	Plugged-in places	The Government is providing funding for electric vehicle infrastructure in London, Milton Keynes and the North East, which are already installing recharging points in their areas. The installation of infrastructure will cost £20 million.	First round (London, Milton Keynes and the North East) ongoing.	http://www.dft.gov.uk/pgr/sustainable/olev/infrastructure/ https://www.sourcelondon.net/ http://www.investmiltonkeynes.com/other/press_release.php?key=84 http://www.chargeyourcar.org.uk/indexx3.php http://nds.coi.gov.uk/clientmicrosite/Content/Detail.aspx?ClientId=202&NewsAreaId=2&ReleaseID=417055&SubjectId=36

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	National	Rail electrification	Electrification program for mainline rail. Electrification of lines between Liverpool, Manchester, Preston, and Blackpool, and electrification of the Great Western Main Line between London and Oxford and Newbury were announced November 2010.	Ongoing	http://webarchive.nationalarchives.gov.uk/+/http://www.dft.gov.uk/pgr/rail/pi/rail-electrification.pdf http://nds.coi.gov.uk/clientmicrosite/Content/Detail.aspx?ClientId=202&NewsAreaId=2&ReleaseID=416742&SubjectId=36
	National	High Speed Rail	Building of new high speed rail lines. These include London to Birmingham and a Y-shaped network to Manchester and Leeds.	Ongoing	http://www.dft.gov.uk/pgr/rail/pi/highspeedrail/
	Scotland	Climate challenge fund	Funds Scottish communities to reduce carbon emissions. Grants are limited to £1 million each and over 250 communities have been funded thus far.	Recently extended to 2011-12	http://www.scotland.gov.uk/Topics/Environment/climatechange/ClimateChallengeFund/aboutttheCCF/overview
	National	Green Investment Bank	The UK Government has committed to introducing a Green Investment Bank, which will offer finance for 'low carbon' investment. The government announced in the 2011 budget that it will capitalise the Green Investment Bank with £3 billion and set it in operation in 2012-13.	2012-13, with borrowing powers from 2014-15	http://cdn.hm-treasury.gov.uk/2011budget_complete.pdf
Government investment - environment	Fund administered nationally. Local Authorities bid for funding.	Local sustainable transport fund	Funding (£560 million over four years to 2014-15) for sustainable transport initiatives to be introduced by local authorities.	Ongoing	http://www.dft.gov.uk/pgr/regional/transportfund/pdf/guidance.pdf
	England	English Woodland Grant Scheme	Six different schemes that provide grant support for landowners who want to create new woodland and carry out sustainable woodland management.	Ongoing	http://www.forestry.gov.uk/ewgs
	England	Environmental Stewardship	Grant funding offered to farmers and landowners who commit to particular land stewardship practices, with different funding available depending on management practices adopted	ongoing	http://www.naturalengland.org.uk/ourwork/farming/funding/es/default.aspx
Support for research and development					
R&D - general and demonstration	National	Low carbon vehicle innovation platform	The government has invested £120 million in the scheme, which includes a competition to demonstrate electric cars in the UK.	Ongoing	http://www.innovateuk.org/ourstrategy/innovationplatforms/lowcarbonvehicles.ashx
	Nationwide	Investment in CCS	Commitment to invest £1 billion in UK's first demonstration CCS project.		http://decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/ccs/ccs.aspx
	National	Carbon capture and storage competition	Competition to provide funding for three further demonstration projects (in addition to the first demonstration project above which has a £1 billion funding commitment).	Ongoing until the four projects are funded.	http://decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/ccs/demo_comp/demo_comp.aspx http://www.decc.gov.uk/assets/decc/legislation/energybill/1_20091215163644_e_@@_ccsfactsheet.pdf
	EU wide	EU support for CCS	The European Union has set aside 300 million EUAs for supporting up to 12 CCS plants and innovative renewable technologies. This scheme also allows for €1.05 billion of European Economic Recovery Plan stimulus spending, including €180 million for projects in the United Kingdom.		http://ec.europa.eu/clima/funding/ner300/index_en.htm#part_3
	National	Marine Renewables Deployment Fund	The Marine Renewable Deployment Fund is a £50 million fund that supports the deployment of wave and tidal energy, in addition to supporting research and infrastructure. It provides a grant towards capital costs (up to 25 per cent) and offers £100 per MWh of electricity produced from eligible sources for up to 7 years. It has four components: the Wave and Tidal-stream Energy Demonstration Scheme, environmental research, related research and infrastructure support.	Ongoing	http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/lc_business/lc_economy/env_trans_fund/marine_fund/marine_fund.aspx http://www.ucl.ac.uk/environment-institute/research/dispatches
	Scotland	Scottish European Green Energy Centre	The Scottish European Green Energy Centre is an independent organisation partially sponsored by the Scottish Government. It facilitates projects targeted at the development, demonstration and deployment of renewable energy.		http://www.segec.org.uk/about-us.aspx
	Scotland	Saltire prize for marine renewables	£10 million will be awarded to the team that can demonstrate (in Scottish waters) a commercially viable wave or tidal stream energy technology that achieves the greatest volume of electrical output over the set minimum hurdle of 100 GWh over a continuous two year period.	Began in 2008 and will end in 2017.	http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Action/leading/saltire-prize
R&D - deployment and diffusion	National	Energy technology institute	The Energy Technology Institute is partly funded by the UK government and aims to demonstrate and develop clean energy technology.		http://www.energytechnologies.co.uk/Home.aspx
	UK	Environmental Transformation Fund	Umbrella funding of up to £400 million covering Carbon Trust, Low-Carbon Buildings Programme, Bioenergy Capital Grants and Bioenergy Infrastructure Schemes, Offshore Wind Capital Grants Programme, Marine Renewables Deployment Fund, Carbon Abatement Technology Demonstration Programme and Hydrogen and Fuel Cell Demonstration Programme.	2008-09 to 2010-11	http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/lc_business/lc_economy/env_trans_fund/env_trans_fund.aspx
	UK	Low carbon investment funding	Grant support (£405 million over 2 years) for low-carbon technologies and 'priority industries'.	Commenced in 2009 and ongoing for 2 years.	http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/lc_business/lc_economy/env_trans_fund/env_trans_fund.aspx
	UK	Low impact buildings innovation platform	Grant funding (£47million over initial three years) to support R&D projects and demonstration projects to develop 'low impact buildings'.	Runs from 2008 to 2011.	http://www.innovateuk.org/ourstrategy/innovationplatforms/lowimpactbuilding.ashx

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Other					
Information provision or benchmarking	National	Energy performance certificates	All commercial and residential buildings in the United Kingdom require an energy performance certificate to be sold. The certificate rates the energy performance of the building.	Ongoing	http://epc.direct.gov.uk/index.html http://webarchive.nationalarchives.gov.uk/ http://www.communities.gov.uk/documents/planningandbuilding/pdf/324459
	National	Display Energy Certificates	All public buildings larger than 1000 square metres must have a Display Energy Certificate showing the energy efficiency of the building in operation for that year.	Ongoing	http://www.communities.gov.uk/publications/planningandbuilding/displayenergycertificates
	National	Indicators NI 185 and NI 186	Under NI 185, local authorities are required to report CO_2 emissions from their operations. NI 186 requires them to report performance in reducing per capita emissions in their area.	Ongoing	
	Scotland	Zero waste fund	A scheme that funds a variety of measures, including services to business, advertising campaigns, voluntary waste agreements and capital investments.	Runs from 2008 to 2011.	http://www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Waste-1/wastestrategy/zero-waste-fund
	National	Energy Bill reporting requirements for government	A requirement of the new Energy Bill is for the government to report every three years on the progress being made to decarbonise electricity supplies and the development and use of carbon capture and storage.	Bill received royal assent in April 2010.	
Labelling scheme	National	Mandatory energy labelling	Labels detailing energy consumption and performance are required for fridges and freezers, washing machines, dryers, combined washer-dryers, dishwashers, lamps, air conditioners and electric ovens.	Ongoing	http://www.defra.gov.uk/environment/business/products/energy/index.htm
	National	Energy star	Voluntary labelling scheme that aims to promote the use of energy efficient office equipment.	Ongoing	http://www.defra.gov.uk/environment/business/products/energy/
	National	Energy Saving Trust Recommended logo	Logos for energy efficient products in various categories.	Ongoing	http://www.energysavingtrust.org.uk/Home-improvements-and-products/About-Energy-Saving-Trust-Recommended-products
	England, Wales, Northern Ireland.	Code for sustainable homes	Code to rate the sustainability performance of homes. It gives homes a star rating based on energy and water usage as well as building materials used in construction. Code is intended to allow homebuilders to demonstrate the environmental sustainability of new houses. All houses built with public grants are required to have carbon emissions in line with Level 3 of the code (25 per cent more efficient than a house built to the 2006 Building Regulation standards).	Ongoing	http://www.breeam.org/page.jsp?id=86 http://www.planningportal.gov.uk/uploads/code_for_sust_homes.pdf http://www.housing.org.uk/Uploads/File/Campaigns/Environment/Green_Homes_Briefing per cent20Jun08.pdf http://www.communities.gov.uk/documents/planningandbuilding/pdf/1766290.pdf http://www.communities.gov.uk/documents/planningandbuilding/pdf/1418945.pdf
	National	Vehicle labelling scheme for new (since 2005) and used vehicles (since 2009).	The UK Fuel Economy Label for new and used cars shows how much carbon dioxide a car emits, the estimated fuel costs for 12 000 miles and the vehicle excise for 12 months.	Ongoing	http://www.vca.gov.uk/fcb/used-car-labelling.asp http://www.vca.gov.uk/additional/files/fcb--co2/point-of-sale-pos-system/used-car-label-spec.pdf
	National (EU directive)	Tyre labelling regulation (1222/2009)	The fuel efficiency, wet grip and external rolling noise performance of tyres will be rated on a scale of A-G. This regulation is an extension of the consumer labelling directive.	Regulation applies from 1st November 2012.	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:342:0046:0058:EN:PDF http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52008SC2860:EN:NOT
Advertising or educational scheme	National (EU directive)	Voluntary Energy Efficiency Agreement with road transport fuel suppliers	The European Commission's Energy Services Directive requires the UK Government to place an obligation on energy suppliers, including road transport fuel suppliers, to provide and promote fuel efficiency improvement measures and/or fuel efficiency audits to their customers. The Directive allows either a mandatory or voluntary approach but states that a voluntary approach must have an effect equivalent to a mandatory approach.	Ongoing	http://www.dft.gov.uk/pgr/sustainable/energy-efficiency/agreement
	National	Safe and Fuel Efficient Driving programme for bus and coach drivers	A demonstration program to show how effective driver development training can be in enhancing the skills of drivers of buses and coaches, especially in reducing fuel costs through better fuel use and improved safety.	Completed.	http://www.dft.gov.uk/pgr/regional/buses/safed/demo-programme/pdf/safedbuscoachfinalreport.pdf http://www.dft.gov.uk/press/speechesstatements/statements/penning20101012
	National	Code of Good Agricultural Practice	Manual providing advice on how to reduce agricultural pollution.	Ongoing	http://archive.defra.gov.uk/foodfarm/landmanage/cogap/index.htm

Policy type	***Jurisdiction***	***Name***	***Description***	***Status and duration***	***References***
Broad target or intergovernmental framework	National	Climate Change Act 2008	Creates a legally binding target for the UK government to cut emissions by 80 per cent of 1990 levels by 2050, with a reduction of at least 34 per cent by 2020, through action in the United Kingdom as well as abroad. The Climate Change Committee is responsible for setting interim 'carbon budgets'.	Ongoing	http://www.decc.gov.uk/assets/decc/85_20090310164124_e_@@_climatechangeactia.pdf
Voluntary agreement	National	Climate change agreements	Climate change agreements provide an 65 per cent discount from the climate change levy for eligible energy intensive businesses that agree to meet targets for reducing emissions. From 1 April 2013 this be increased to 85 per cent.	Provisionally extended until 2017. A review of the agreements was also announced in January 2011.	http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/ccas/ccas.aspx

United States

The stocktake for the United States only covers federal government policies, similar policies used in multiple states, schemes in which multiple states participated, and other state government policies in the five states with the largest greenhouse gas emissions (California, Texas, Illinois, Ohio and Pennsylvania).
FY US fiscal year (October to September).

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Explicit carbon prices					
Emissions trading scheme - cap and trade	Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont.	Regional Greenhouse Gas Initiative (RGGI)	The RGGI covers ten US States and aims to reduce emissions in the electricity generation sector by 10 per cent below 2009 levels by 2018. All fossil fuel-fired electricity generators with a capacity of 25 MW or greater must hold allowances equal to their CO2 emissions over three-year control periods (the first of which runs from January 2009 to December 2011). Total emissions are capped at 188 million US (short) tons (170.6 Mt) CO2 per year until 2014. Most permits (allowances) have been auctioned to date. Generators can surrender allowances issued by any of the ten participating states, and most State Governments use auction revenues to fund other policies (such as energy efficiency and renewable energy schemes).	Ongoing, although New Jersey may withdraw from the scheme.	http://www.rggi.org http://www.env-ne.org/projects/open/p/id/331/program/Climate%20Change%20Solutions
	Arizona, California, Montana, New Mexico, Oregon, Utah, Washington.	Western Climate Initiative (WCI) Cap-and-Trade Program	The Western Climate Initiative (WCI) is an agreement between seven US states and four Canadian provinces (British Columbia, Manitoba, Ontario and Québec) to implement a cap-and-trade emissions trading scheme. The WCI aims to reduce emissions to 15 per cent below 2005 levels by 2020. Electricity and large industrial facilities were scheduled to be covered by the ETS in 2012, with the scheme expanding to include transport and other fuels in 2015. Each jurisdiction would have the discretion to auction or freely allocate allowances (permits) to emissions-intensive trade-exposed firms. However, at least 10 per cent of allowances must be auctioned in the first year, and at least 25 per cent by 2020. At this stage, it appears that only California (among US states) is fully committed to implementing an emissions trading scheme by 2012.	Introduction of an ETS has been scheduled for January 2012 in California. Some other states may implement an ETS in the future.	http://www.westernclimateinitiative.org
	California	California Emissions Trading Program	The California cap-and-trade ETS is scheduled to commence in 2012 as part of the Western Climate Initiative. The scheme is designed to reduce emissions by 15 per cent below 2012 levels by 2020. The emissions cap will decline by around 2 per cent each year until 2015, and then 3 per cent per year thereafter. Initially, electricity (including imports from other states) and large industrial facilities will be included, with natural gas and transportation fuels to be covered from 2015 (there will be a one-off doubling of the number of permits in the scheme once transport fuels are included). Offsets from other sectors (such as forestry or agriculture) can be used for compliance, up to a limit. Some permits will be allocated to emissions-intensive trade-exposed firms.	Scheduled to commence in 2012.	http://www.arb.ca.gov/newsrel/newsrelease.php?id=165 http://www.pewclimate.org/states/news/2010/11/california-greenhouse-gas-emissions-trading-design-released
	New Mexico	New Mexico Greenhouse Gas Cap and Trade Program	A cap-and-trade ETS that is scheduled to commence in 2012 as part of the Western Climate Initiative. (However, implementation is contingent on at least 100 Mt CO2-e being capped in other US states that are part of the WCI.) The scheme is designed to cover electricity generation and industrial processes, with a target of reducing emissions by 2 per cent each year. Some offsets will be permitted.	Scheduled to commence in 2012.	http://www.nmenv.state.nm.us/cc
	Illinois, Iowa, Kansas, Michigan, Minnesota, Wisconsin.	Midwestern Greenhouse Gas Reduction Accord	An agreement by six US state governments and one Canadian province to implement a cap-and-trade ETS. The Advisory Group for the scheme recommended that it commence in 2012 and aim to reduce emissions by 20 per cent below 2005 levels by 2020, and by 80 per cent by 2050. It would cover electricity generation (and electricity imports), industrial processes, fuels used to heat buildings, and transport fuels. Permits would be allocated to emissions-intensive firms that face limited ability to pass through costs. Complementary policies are also likely to be introduced by participating states.	Implementation is uncertain.	http://midwesternaccord.org/Presentation.pdf http://www.pewclimate.org/what_s_being_done/in_the_states/mggra
	Florida	Florida Electric Utility Cap-and-Trade	A cap-and-trade ETS might be developed for the electricity sector in Florida, although the legislature has not yet passed legislation to implement such a scheme. Many scheme details are yet to be determined.	Implementation is uncertain.	http://www.dep.state.fl.us/climatechange/files/action_plan/chap4_cap_trade.pdf http://www.flclimatechange.us http://www.pewclimate.org/node/6020
Subsidies and taxes					
Capital subsidy	Federal	Section 1603 Renewable Energy Grant (Treasury Grant)	Cash grants to eligible renewable energy investments (facility construction) that are brought into service from 2009. The grant is 30 per cent of costs for fuel cells, solar, small wind, biomass, landfill, geothermal (other than heat pumps) waste and marine, and 10 per cent for geothermal heat pumps, micro-turbines and combined heat and power. Firms can choose whether to receive this grant or, alternatively, can receive either the Business Energy Investment Tax Credit or the Renewable Electricity Production Tax Credit.	Ongoing	http://www.treas.gov/recovery/1603.shtml http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US53F&re=1&ee=0
	Federal	Repowering Assistance Program	Subsidies to biorefineries (up to US$5 million or 50 per cent of eligible project costs, whichever is less) for projects that replace fossil fuel use with renewable biomass, or that generate energy from renewable biomass. Payments are for up to 3 years, and only for biorefineries in rural areas. Available funding for this program was US$20 million in 2009, which will remain available until expended.	Ongoing	http://www.rurdev.usda.gov/ia/rbcs_9004_Repowering_Assistance.html
	Federal	Clean Coal Investment Tax Credit	Tax credits for projects that generate electricity from Integrated Gasification Combined Cycle (IGCC) technologies or other 'advanced' methods that reduce the CO2 emissions from coal-fired generation. The tax credit is for 20 per cent of costs for IGCC projects (up to US$800 million in total for the scheme) and 15 per cent for other 'advanced coal-based generation technologies' (up to US$500 million). Foregone revenues were US$240 million in 2010.	Ongoing	http://nepinstitute.org/get/CRS_Reports/CRS_Energy/Electric_Power_Generation/Clean_Coal.pdf

Policy type	Jurisdiction	Name	Description	Status and duration	References
	Arkansas, California, Colorado, Maryland, Minnesota, New Hampshire, New Jersey, New York, Pennsylvania, Washington, Vermont, District of Columbia.	Capital subsidies for renewable energy generation	Some states provide subsidies for the installation of renewable energy generation. Eligible generation sources and payment rates vary across states. Solar photovoltaic (PV) and solar hot water are covered by most states' schemes, and wind is covered by around half. Subsidies are provided for residential and/or commercial projects, depending on the state.	Ongoing	http://www.dsireusa.org/incentives/index.cfm?SearchType=Rebate&EE=0&RE=1
	Federal and state	State Energy-Efficient Appliance Rebate scheme	This one-off scheme involved state governments providing rebates to consumers when replacing used appliances with 'ENERGY STAR' qualified appliances. Rebate schemes differed between states although most covered air conditioners,refrigerators, clothes washers, dishwashers, freezers, hot water heaters, oil and gas furnaces and geothermal heat pumps. Each state had a set allocation of funding from the federal government (US$300 million under the American Recovery and Reinvestment Act of 2009 (US)).	The scheme has expired in most states but remains active in some.	http://www1.eere.energy.gov/recovery/appliance_rebate_program.html http://www.energysavers.gov/financial/70022.html
	California	California Solar Initiative	Subsidies for solar energy systems. These consist of upfront cash payments (the Expected Performance Based Buydown and the Single family Affordable Solar Homes scheme) and performance based incentives (feed in tariffs for the first five years of operation of solar PV systems).	Ongoing	http://www.cpuc.ca.gov/PUC/energy/Solar http://www.gosolarcalifornia.ca.gov/csi/index.php
	California	Self-Generation Incentive Program	Payments for distributed energy systems including wind turbines, fuel cells and 'advanced energy storage' systems. Payments are US$1.50/W for wind, US$2.50/W for fuel cells using non-renewable fuels, US$4.50/W for fuel cells using renewable fuel, and US$2/W for advanced energy storage systems.	Ongoing	http://www.cpuc.ca.gov/PUC/energy/DistGen/sgip https://energycenter.org/index.php/incentive-programs/self-generation-incentive-program
	California	Emerging Renewables Program	Payments for the installation of grid-connected small wind and fuel cell renewable energy electricity generation systems (up to 50 kW). The rate paid is up to US$3/W, depending on the type and size of the system (with higher rates for ‘affordable housing’ projects).	Ongoing	http://www.energy.ca.gov/renewables/emerging_renewables http://www.consumerenergycenter.org/erprebate
	California	New Solar Homes Partnership	Subsidies to builders of new residential properties for the installation of solar energy systems. Subsidies vary by the housing type and the expected performance of the system. The base subsidy is US$2.50/W, with higher rates for builders of multiple houses that install solar panels and those that install solar panels on ‘affordable housing’ projects.	Ongoing	http://www.gosolarcalifornia.ca.gov/about/nshp.php
	California	Plug-in hybrid and zero emission light-duty vehicle rebates	Rebates of up to US$5000 for the purchase or lease of light-duty zero-emissions and plug-in hybrid vehicles, and rebates up to US$20 000 for approved zero-emissions commercial vehicles. US$4 million in funding has been provided for this program.	Ongoing	https://energycenter.org/index.php/incentive-programs/clean-vehicle-rebate-project
	Illinois	Alternate Fuels Rebate Program	A rebate of 80 per cent of the incremental cost of purchasing an 'alternative fuel' vehicle, up to a limit of US$4 000, and a rebate of 80 per cent of the cost of converting a conventional or hybrid electric vehicle to 'alternative fuels' using a certified conversion (limit of US$4000). There are also rebates for the incremental cost of purchasing 'alternative fuels' (E85, biodiesel, natural gas, electricity, propane, hydrogen) of up to US$450 per year. Vehicles or conversion systems must be purchased from a company based in Illinois.	Ongoing	http://www.illinoisgreenfleets.org
	Pennsylvania	Sunshine Solar Rebate Program	Rebates to households and small commercial entities (with no more than 100 full-time employees) that install solar PV and thermal energy generation. Rebates apply to a maximum of 10 kW for residential PV and to maximum of 100 kW for businesses. Solar thermal rebates are up to US$5000 for households (with higher rates for low-income households) and US$50 000 for businesses. The scheme has US$100 million in funding.	Ongoing	http://www.portal.state.pa.us/portal/server.pt/community/grants_loans_tax_credits/10395/pa_sunshine_solar_program/821790
Feed-in tariff	California, Hawaii, Minnesota, New Jersey, South Carolina, Washington.	Feed-in tariffs	Electricity utilities are required to provide feed-in tariffs for renewable energy generation in some states. Eligible renewable sources, payment rates and maximum payments vary across states. Most state schemes cover solar PV, solar thermal, wind, landfill gas and biomass. In some states these schemes are linked to Renewable Portfolio Standard (RPS) obligations, and some states offer additional 'Solar Renewable Energy Credits' for solar PV generation.	Ongoing	http://www.dsireusa.org/incentives/index.cfm?SearchType=Production&EE=0&RE=1
Tax rebate or credit	Federal	Business Energy Investment Tax Credit	A corporate tax credit of 30 per cent of expenditures for capital investments and installation of solar energy systems, fuel cells and small wind turbines (up to 100 kW capacity), and of 10 per cent of expenditures for capital investments in geothermal, microturbines (up to 2 MW) and combined heat and power (up to 50 MW). Firms can choose whether to accept this tax credit or, alternatively, can instead choose either the Renewable Energy Production Tax Credit or an equivalent Section 1603 Treasury grant. The value of tax credits was US$130 million in fiscal year (FY) 2010.	Ongoing	http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US02F&re=1&ee=0
	Federal	Renewable Electricity Production Tax Credit	An annual tax credit for renewable energy production from qualified facilities for the first 10 years of their operation. The rate in 2010 for wind, closed-loop biomass, solar and geothermal was US$0.022/kWh. Other renewable energy sources received US$0.011/kWh. Firms can choose to accept this tax credit or, alternatively, can choose either the Business Energy Investment Tax Credit or an equivalent Section 1603 Treasury Grant.	Ongoing	http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US13F&re=1&ee=0
	Federal	Renewable Energy Production Incentive	Annual government payments of US$0.021/kWh (US$0.015/kWh in 1993 dollars, indexed to inflation) for the first 10 years of operation of eligible renewable energy generation facilities, including solar, wind, geothermal, biomass (excluding municipal solid waste), landfill gas, livestock methane, or ocean resources. Payments are provided to not-for-profit electrical cooperatives, public utilities, state governments, territories, the District of Columbia and tribal governments. In 2009, payments (for 2008 production) totalled around US$4.2 billion.	Ongoing	http://apps1.eere.energy.gov/repi/about.cfm
	Federal	Advanced Energy Manufacturing Tax Credit	An investment tax credit of 30 per cent for facilities that manufacture 'advanced energy' equipment. This covers investments in new, expanded, or re-equipped manufacturing projects. A competitive bidding process is used to allocate tax credits. Eligible 'advanced energy' facilities include those that manufacture technology for the production of renewable energy, energy storage, energy conservation, plug-in or hybrid motor vehicles, more efficient transmission and distribution of electricity, and carbon capture and sequestration. Projects must be commissioned before 17 February 2013. The scheme was provided US$2.3 billion in funding under the American Recovery and Reinvestment Act of 2009 (US).	Ongoing	http://www.energy.gov/recovery/48C.htm http://www.whitehouse.gov/the-press-office/president-obama-awards-23-billion-new-clean-tech-manufacturing-jobs

Policy type	Jurisdiction	Name	Description	Status and duration	References
	Federal	Commercial Buildings Tax Deduction	A tax deduction of US$1.80 per square foot (US$19.38 per square metre) of floorspace for owners of new and existing commercial buildings who install interior lighting, a building envelope that meets certain standards, or heating, cooling, ventilation and/or hot water systems that reduce the building's total energy and electricity costs by 50 per cent or more (compared to a building that meets minimum American Society of Heating, Refrigerating and Air-Conditioning Engineers Standard 90.1-2001). In addition, there are deductions of US$0.60 per square foot (US$6.46 per square metre) for buildings where individual lighting, building envelope modifications, or heating and cooling systems 'meet target levels that would reasonably contribute to an overall building savings of 50 per cent if additional systems were installed'.	Ongoing	http://www.efficientbuildings.org http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US40F&re=0&ee=1
	Federal	Residential Energy Property Credit	An income tax credit for energy efficiency investments in existing residential dwellings. The credit in 2011 is for 10 per cent of the cost of qualifying investments, with the maximum amount depening on the type of investment made (to a limit of US$500). Eligible investments include adding insulation, energy efficient exterior windows and energy-efficient heating and air conditioning systems. The credit applies to energy efficiency improvements in the building envelope of existing houses, and the purchases of high-efficiency heating, cooling and water-heating equipment. Labour costs for heating, cooling and water-heating equipment installation are also eligible. The total value of tax credits was US$3.19 billion in 2010.	Ongoing	http://www.energystar.gov/index.cfm?c=tax_credits.tx_index
	Federal	Residential Energy Efficient Tax Credit	A 30 per cent tax credit for expenditures, including onsite labour costs, on 'alternative' or renewable energy equipment in residential dwellings. Eligible equipment includes solar water heaters, solar electricity equipment and geothermal heat pumps, as well as wind turbines and qualified fuel cells. The total value of tax credits was US$220 million in 2010.	Ongoing	http://www.energystar.gov/index.cfm?c=tax_credits.tx_index
	Federal	Energy Efficient Home Credit	Tax credits for builders of energy-efficient houses. The credit is US$2000 for houses that reduce energy consumed for heating and cooling by 50 per cent compared to the International Energy Conservation Code standard, meet minimum efficiency standards set by the Department of Energy, and use improvements to building envelope components to meet at least 20 per cent of the reduction in energy use. There is also a US$2000 credit for manufactured houses that meet these requirements, with additional amounts in some circumstances.	Ongoing	http://www.irs.gov/businesses/small/industries/article/0,,id=155445,00.html
	Federal	Energy-Efficient Appliance Manufacturing Tax Credit	Tax credits are provided to manufacturers of high-efficiency residential clothes washers, refrigerators, and dishwashers, with the amount per unit based on the type of appliance, its energy efficiency and the date of manufacture. Credit amounts are up to US$75 for a dishwasher, US$225 for a clothes washer and US$200 for a refrigerator. Each manufacturer is limited to a total of US$25 million for all tax credits under the scheme. The total value of tax credits was US$150 million in 2010.	Ongoing	http://www.irs.gov/businesses/corporations/article/0,,id=208024,00.html
	Federal	Alcohol Fuel Credit	Producers of ethanol that is used as a road transport fuel receive a tax credit of US$0.45/gallon (US$0.12/L) of ethanol produced (including the ethanol component of petrol-ethanol blends). Additional tax credits are provided to producers of 'cellulosic ethanol', such that the total rate is US$1.01/gallon (US$0.27/L). Eligible small producers can receive an additional US$0.10/gallon (US$0.03/L) over the first 15 million gallons of biofuel produced each year. In FY 2010, foregone excise tax revenues were US$5.68 billion and foregone income tax revenues were US$70 million.	Ongoing	http://www.afdc.energy.gov/afdc/laws/laws/US/incentive/3234 http://www.irs.gov/pub/irs-pdf/p510.pdf
	Federal	Biodiesel Fuel Credit	Producers of biodiesel (and renewable diesel) that is used as a road transport fuel receive a tax credit of US$1/gallon (US$0.26/L) of biodiesel produced (including the biodiesel component of diesel-biodiesel blends). Eligible small producers can receive an additional US$0.10/gallon (US$0.03/L) over the first 15 million gallons of biofuel produced each year. These tax credits can also be taken as a payment, rather than as credits against excise or income taxes. In FY 2010,	Ongoing	http://www.afdc.energy.gov/afdc/laws/laws/US/incentive/3234 http://www.irs.gov/pub/irs-pdf/p510.pdf
	Federal	Renewable Diesel Credit	Tax credit US$1.00 per gallon of diesel derived from biomass.	Ongoing	http://www.irs.gov/pub/irs-pdf/p510.pdf
	Federal	Alternative Fuel Production Credit	The Alternative Fuel Credit involves the provision of excise tax credits to producers of 'alternative' fuels, including compressed natural gas, liquefied natural gas, liquefied hydrogen, liquefied petroleum gas, P-series fuel, liquid fuel derived from coal (provided that 75 per cent of the facility's total CO_2 emissions are separated and sequestered), and compressed or liquefied gas derived from biomass. Credits are provided at US$0.50 per gallon of eligible fuels. Foregone government reveue was $170 million in 2010.	Ongoing	http://www.afdc.energy.gov/afdc/laws/laws/US/incentive/3234 http://www.irs.gov/pub/irs-pdf/p510.pdf
	Federal	Alternative Fuel Infrastructure Tax Credit	A tax credit for the cost of 'alternative' fuelling equipment. Eligible fuels include natural gas, liquefied petroleum gas, hydrogen, electricity, E85 and diesel fuel blends containing a minimum of 20 per cent biodiesel. Current tax credit amounts are for 50 per cent of the cost (capped at US$2000 for personal property and US$50000 for business use, with the exception of hydrogen fuelling equipment, which is capped at US$200 000).	Ongoing	http://www.irs.gov/pub/irs-pdf/f8911.pdf http://www.jct.gov/publications.html?func=startdown&id=3716
	Federal	Qualified Plug-in Electric Drive Motor Vehicle Tax Credit	A tax credit for the purchase of new qualified plug-in electric drive motor vehicles. The minimum credit is US$2500 plus US$417 per kWh of battery capacity in excess of 4 kWh, and up to a maximum of US$7500 to US$15 000, depending on the vehicle's traction, battery capacity and gross weight rating. The scheme will be phased out for each manufacturer after they have sold 200,000 qualified vehicles (after 31 December 2009). There is also a tax credit of 10 per cent of conversion costs for qualified plug-in electric vehicle conversions (capped at US$4000).	Ongoing, with an automatic phase-out as part of the scheme design.	http://www.fueleconomy.gov/feg/taxevb.shtml http://www.irs.gov/pub/irs-drop/n-09-54.pdf
	Federal	Fuel Cell Motor Vehicle Tax Credit	Tax credits of up to US$4000 for the purchase of qualified light-duty fuel cell vehicles. There are also tax credits for medium and heavy duty vehicles, with the amount based on the vehicle weight.	Ongoing	http://www.afdc.energy.gov/afdc/laws/laws/US/incentive/3234
	Federal	Credit for Production from Advanced Nuclear Facilities	A production tax credit of US$0.018/kWh for the generation of electricity from 'advanced' nuclear facilities, with a limit of US$125 million in tax credits per 1000 MW of allocated capacity in any given year. Tax credits can only be claimed for the first eight years after the facility is placed in service, and the credit applies to only the first 6000 MW (electrical) of new generation from nuclear energy in the United States.	Ongoing	http://www.nirs.org/factsheets/productiontaxcredits.htm
	Federal	Refined Coal and Indian Coal Tax Credit	Tax credits for the production of refined coal (US$4.375 per US (short) ton) and Indian coal (US$2 per US ton) (US$4.82/tonne and US$2.20/tonne respectively).	Ongoing	

Policy type	Jurisdiction	Name	Description	Status and duration	References
	Federal	CO2 Capture and Sequestration Tax Credit	US$10 tax credit per tonne of CO2 captured and transported from an industrial source for use in enhanced oil recovery (for the first 75 Mt CO2, and on the condition that all CO2 is permanently stored), and a tax credit of US$20 per tonne for CO2 captured and transported from an industrial source for permanent geological storage. Only facilities that capture at least 500 000 tonnes of CO2 per year are eligible.	Ongoing	
	Federal	Accelerated depreciation of renewable energy investments	Accelerated depreciation of investments in renewable energy technologies for tax purposes, through the Modified Accelerated Cost-Recovery System. The depreciation schedule is five years for solar-electric and solar-thermal technologies, fuel cells, geothermal electric equipment, geothermal heat pumps, small wind generators, and combined heat and power (for biomass equipment, the depreciation schedule is seven years). In addition, there is a 100 per cent first-year bonus depreciation for property placed in service between 8 September 2010 and 1 January 2012. During 2012 there will be bonus depreciation of 50 per cent.	Ongoing	http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US06F&re=1&ee=0
	Federal	Accelerated Recovery Period for Depreciation of Smart Meters and Smart Grid Systems	Accelerated depreciation for qualified 'smart' electricity meters and grid equipment. In most cases, costs can be recovered over a 10-year period rather than the usual 20-year period for such equipment.	Ongoing	http://www.kema.com/services/consulting/utility-future/smart-grid/accelerated-depreciation.aspx
	Federal	Accelerated Amortization for Atmospheric Pollution Control Facilities	A portion of the costs of certain air pollution control facilities can be amortised by power plant owners over 60 months if they were in operation before 1976. In addition, there is a seven year recovery period for 60 per cent of the cost of such pollution control facilities that are used by primarily coal-fired electricity generation plants that began operation after 1975.	Ongoing	
	Federal	Publicly Traded Partnership Income Treatment of Alternative Fuels and Industrial Source CO2	Public traded partnerships are permitted, for tax purposes, to treat income derived from the transport or storage of certain 'alternative fuels' and industrial-source anthropogenic CO2 as qualifying income for the purposes of publicly traded partnership rules.	Ongoing	
	State	State incentives for biofuels	Tax credits and subsidies are provided for the production of biofuel and 'alternative' fuel in some states.	Ongoing	http://www.afdc.energy.gov/afdc/laws
	California	Clean Vehicle Rebate Project	Tax rebates of up to US$5000 for approved light-duty zero-emissions vehicles and plug-in hybrid vehicles, and of up to US$20 000 for approved zero-emissions commercial vehicles.	Ongoing	https://energycenter.org/index.php/incentive-programs/clean-vehicle-rebate-project
	Illinois	Special Assessment for Solar Energy Systems	Solar energy equipment can be valued at no more than conventional energy systems for property tax purposes.	Ongoing	http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=IL01F&re=1&ee=0
	Illinois	Solar and Wind Energy Rebate Program	Tax rebates for the installation of solar and wind energy systems of up to 30 per cent of total project costs for residential and business applicants, and 50 per cent for public sector and non-profit entities. The maximum rebate is US$50 000. Solar-thermal systems must be at least 1 kW capacity and meet technical criteria. Wind systems must have a capacity of 1 to 100 kW. Projects may be funded from other government schemes provided that the rebate does not exceed 75 per cent of project costs.	The scheme for 2011 has closed although more funding is expected in future years.	http://www.commerce.state.il.us/dceo/Bureaus/Energy_Recycling/Energy/Clean+Energy/01-RERP.htm
	Hawaii, Iowa, Maine, Maryland, Michigan, Montana, New York, South Dakota, Vermont, District of Columbia.	Excise concessions for ethanol	Ethanol is taxed at a lower rate than petrol in some states. These tax concessions are often applied to the two ethanol-petrol blends that can be legally sold in the United States — E10 (petrol blended with 10 per cent ethanol, also called ‘gasohol’ in the United States) and E85 (petrol blended with 85 per cent ethanol).	Ongoing	http://www.fhwa.dot.gov/policyinformation/statistics/2009
	Illinois	Ethanol Tax Concessions	Sales and use taxes apply to only 80 per cent of the proceeds from the sale of E10 (10 per cent ethanol) fuels until 31 December 2013. Fuels containing between 70 per cent and 90 per cent ethanol are exempt from sales and use taxes before 31 December 2013.	Ongoing, expires 31 December 2013.	http://www.afdc.energy.gov/afdc/laws/law/IL/5996
	Illinois	Biodiesel Tax Concessions	Sales and use taxes apply to only 80 per cent of the proceeds from the sale of biodiesel blended fuels containing between 1 per cent and 10 per cent biodiesel, until 31 December 2013. Fuels containing more than 10 per cent biodiesel are exempt from sales and use taxes before 31 December 2013.	Ongoing, expires 31 December 2013.	http://www.afdc.energy.gov/afdc/laws/law/IL/5697
	Ohio	Biofuels Retail Tax Credit	Tax credits for retailers of E85 and fuel blends containing at least 20 per cent biodiesel. Credits are US$0.13/gallon (US$0.49/L) of E85 or biodiesel blend sold. In addition, there is a tax credit of US$0.075/gallon (US$0.28/L) for blends of at least 10 per cent but less than 20 per cent biodiesel and US$0.0375/gallon (US$0.14/L) for blends of at least 6 per cent but less than 10 per cent biodiesel.	Ongoing	http://www.afdc.energy.gov/afdc/laws/law/OH/6318
	Ohio	Ethanol Production Investment Tax Credits	Certified ethanol production plants can receive credits against state corporation franchise and income taxes. Credits are 50 per cent of the investment up to a maximum US$5000 per plant, and are available until 2013 (for corporation franchise tax) and 2012 (for income tax).	Ongoing	http://www.afdc.energy.gov/afdc/laws/law/OH/6636
	Texas	Renewable Energy Systems Property Tax Exemption	Property tax reductions that reduce the appraised value of properties by the value of the installation/construction of solar, wind or biomass energy generation devices (provided the energy is used on-site). energy devices that are primarily for the production and distribution of thermal, mechanical or electrical energy for on-site use. These reductions apply to residential and commercial entities.	Ongoing	http://www.seco.cpa.state.tx.us/re_incentives-taxcode-statutes.htm
	Texas	Solar and Wind Energy Device Franchise Tax Deduction	Franchise tax (corporate tax) concession allowing entities to deduct the cost of solar and wind energy devices from the amount of tax payable. The deduction is up to 10 per cent of the amortised cost of the system.	Ongoing	http://www.seco.cpa.state.tx.us/re_incentives-taxcode-statutes.htm#171107
Tax exemption	Federal	Energy Conservation Subsidy Exclusion	An exemption from corporate and personal income taxes for 'energy conservation subsidies' that are paid by public utilities to their customers (residential or corporate). However, if tax credits or deductions are received by the customer for such a project, the value of the conservation subsidy must be deducted from the project cost for the purpose of determining the deduction. Eligible conservation measures include installations and modifications designed to reduce the use of electricity or natural gas on residential properties, or measures to improve the management of energy demand.	Ongoing	http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US31F&re=1&ee=0

Policy type	Jurisdiction	Name	Description	Status and duration	References
	Federal	Alternative Fuel Tax Exemption	'Alternative' fuels that are designated as 'nontaxable' are exempt from federal fuel taxes. This includes the use of such fuels in a farm for farming purposes; in some intercity, local and school buses; exclusively by nonprofit educational organisations; and exclusively by a state, the District of Columbia, or a political subdivision. The exemption does not apply to entities that are not liable to pay excise taxes on transport fuels.	Ongoing	http://www.irs.gov/publications/p510/index.html
	Federal	Idle Reduction Equipment Excise Tax Exemption	Federal taxes on the sale of heavy-duty highway trucks and trailers are exempted for on-board idle-reduction devices and 'advanced' insulation. This applies to the retrofitting of equipment on existing vehicles.	Ongoing	http://www.epa.gov/smartway/transport/what-smartway/idling-reduction-fet.htm
	California	Property Tax Exclusion for Solar Energy Systems	Some types of solar energy systems are exlcuded from property tax if installed between 1 January 1999 and 31 December 2016. These include solar space conditioning systems, solar water heating, active solar energy systems, solar process heating systems, solar PV, solar thermal electric and solar mechanical energy (but not pool heating). The exemption is 100 per cent of system value (or 75 per cent of system value for dual-use equipment).	Ongoing	http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CA25F&re=1&ee=0
	California	Sales Tax Exemption for Alternative Energy Manufacturing Equipment	Exemption from state sales and use taxes for expenses incurred in the design, manufacture, production or assembly of renewable energy, combined heat and power, and 'alternative transportation' equipment. This includes solar, biomass, wind, geothermal, and hydro under 30 MW.	Ongoing	http://www.treasurer.ca.gov/caeatfa/sb71/index.asp
	Illinois	Sales tax exemptions for High Impact Businesses	Exemption of state and local sales taxes on building materials for wind power facilities designated a 'High Impact Business'. The facility must be new or an expansion that is placed in service after 1 July 2009 and must use turbines of 500 kW or greater.	Ongoing	http://www.commerce.state.il.us/dceo/Bureaus/Business_Development/Tax+Assistance/HIB.htm
	Illinois	Commercial Wind Energy Property Valuation	Favourable tax treatment of wind energy devices larger than 500 kW that produce electricity for commercial sale. Wind assets are to be valued at US$360 000 per MW capacity for tax purposes (annually adjusted for consumer price inflation) from the ten years from 2007. Since Illinois assesses property at a third of its fair cash value for property taxes, the assessed value is US$119 988/MW in practice. In addition, there is an allowance for the physical depreciation of the asset.	Ongoing	http://www.revenue.state.il.us/LocalGovernment/PropertyTax/windenergydevice.pdf
	Ohio	Energy Conversion Facilities Tax Exemptions	Property used in energy conversion, thermal efficiency improvements and the conversion of solid waste to energy is exempted from real and personal property taxes, state sales and use taxes, and the corporate franchise tax.	Ongoing	http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=OH37F&re=1&ee=0
	Ohio	Qualified Energy Project Tax Exemption	Owners and lessees of renewable, clean coal, nuclear and co-generation energy projects are exempted from public utility tangible personal property tax. To qualify, owners or lessees must make an application before 31 December 2013 (or 31 December 2011 for renewable energy projects). Accepted projects remain tax exempt subject to certain conditions, including the 'Ohio Jobs Requirement.' For projects with a capacity over 250 kW, the tax exemption is replaced with a 'payment in lieu' of tax, which varies by project type and the percentage of Ohio-based employees.	Ongoing	http://development.ohio.gov/Business/AlternativeEnergyTaxExemption.htm
	Ohio	Improving Air Quality in Ohio Tax Exemptions	Tax exemptions for qualifying air pollution reduction projects, air pollution waste treatment, energy efficiency or conservation projects, and projects using renewable energy or biomass (including ethanol). The exemptions are from tangible personal property tax, real property tax, part of the corporate franchise tax, and the sales and use tax.	Ongoing	http://www.ohioairquality.org http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=OH01F&re=1&ee=0
	Pennsylvania	Property Tax Assessment for Commercial Wind Farms	Wind turbines and related equipment are generally not included in property value assessments for tax purposes.	Ongoing	http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=PA26F&re=1&ee=0
	Texas	Solar and Wind Energy Business Franchise Tax Exemption	Franchise tax (corporate tax) exemptions for firms that are engaged solely in manufacturing, selling or installing solar and wind energy devices.	Ongoing	http://www.seco.cpa.state.tx.us/re_incentives-taxcode-statutes.htm#171
	Texas	Memorial Day Weekend Sales Tax Holiday for Energy-Efficient Products	ENERGY STAR rated products are exempted from the Texas sales and use tax for a three-day period each year, coinciding with Memorial Day in May. Eligible products include air conditioners, refrigerators, clothes washers, dishwashers, dehumidifiers, ceiling fans, incandescent and fluorescent light bulbs, and programmable thermostats.	Ongoing	http://www.window.state.tx.us/taxinfo/taxpubs/tx96_1331
	Texas	Ethanol and Biodiesel Blend Tax Exemption	Exemption of the biodiesel or ethanol proportion of blended fuel containing taxable diesel from fuel taxes on diesel.	Ongoing	http://www.afdc.energy.gov/afdc/laws/law/TX/5641
Preferential, low-interest or guaranteed loan	Federal	Biorefinery Assistance Program	Loan guarantees for the development, construction and retrofitting of commercial-scale biorefineries to produce 'advanced biofuels' (with eligible technologies). The maximum loan guarantee is for US$250 million. The maximum guarantee percentage on principal and interest declines with the size of the loan, according to a schedule. US$293 million in funding was available in FY 2010.	Ongoing	http://www.rurdev.usda.gov/rbs/busp/baplg9003.htm
	Federal	Loan Guarantee Program	Financial support for projects that use new or improved technologies (at the early commercial use stage) to avoid, reduce or sequester greenhouse gas and other pollutant emissions. This includes projects in renewable energy, energy efficiency, 'advanced' nuclear energy, 'clean coal' technologies and 'advanced' transmission and distribution (under the 'Section 1703' and 'Section 1705' components), as well as 'advanced' technology vehicle manufacturing (Advanced Technology Vehicle Manufacturing Loan Program). In early 2011, there was around US$17 billion in loans or loan guarantees for projects, with a total cost of around US$26 billion (for over 23 projects).	Ongoing	http://www.lgprogram.energy.gov
	Federal	Advanced Technology Vehicle (ATV) Manufacturing Loan Program	Direct loans for up to 30 per cent of the cost of re-equipping, expanding or establishing advanced-technology vehicle-manufacturing facilities in the United States (including facilities to produce qualified ATV components). ATVs qualify if they are light-duty or ultra-efficient and meet federal emissions standards and fuel efficiency requirements. This scheme is part of the Loan Guarantee Program.	Ongoing	http://lpo.energy.gov/?page_id=43
	Federal	Energy Efficient Mortgages	Federal government insurance of mortgages that either finance energy efficiency improvements to a house (including renewable technologies), or are for new energy efficient houses.	Ongoing	http://www.resnet.us/ratings/mortgages http://www.energystar.gov/index.cfm?c=mortgages.energy_efficient_mortgages

Policy type	Jurisdiction	Name	Description	Status and duration	References
	Federal	Qualified Green Building and Sustainable Design Project Bonds	Bonds to finance the construction of projects on brownfield sites (that is, land previously used for buildings or industry), where buildings must meet a minimum Leadership in Energy and Environmental Design standard. This includes energy efficient design measures and the use of 'alternative' energy sources. The bonds are issued by state or local governments but the scheme is administered at the federal level.	Ongoing	
	Illinois	Green Energy Loan Program (Cultivate Illinois)	Reduced interest rates on loans for certain energy efficiency and renewable energy projects to businesses, non-profit entities and local governments. Loans are from US$10 000 to US$10 million and provided through eligible banks in Illinois.	Ongoing	http://www.treasurer.il.gov/programs/cultivate-illinois/green-energy.aspx
	Illinois	Financing Green Facilities	Tax-exempt bonds are provided to commercial and non-profit entities for renewable energy and energy efficiency projects that meet 'public benefit' requirements.	Ongoing	http://www.il-fa.com/green/ http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=IL46F&re=1&ee=0
	Ohio	Advanced Energy Job Stimulus Fund	Loans for the development, production and use of 'advanced energy' technologies in Ohio. A total of US$150 million is to be provided over three years, of which US$66 million is for 'clean coal' technology and US$84 million is for non-coal projects. Financing is provided through conduit bonds that are exempt from state income, real property, sales and use taxes, and may be exempt from general income tax.	Ongoing; funding is available until June 2011.	http://www.ohioairquality.org http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=OH26F&re=1&ee=0
	Ohio	Energy Conservation for Ohioans (ECO-Link) Program	Interest rates on loans are reduced by three per cent for efficiency and renewable energy investments in existing single-family dwellings. Loans are available for energy-efficient appliances, water heaters, heating and cooling, 'weatherization' products, and renewable energy systems (less than 100 kW for wind).	Ongoing	http://tos.ohio.gov/ForYou/Default.aspx?Section=ECO
	Pennsylvania	Alternative and Clean Energy Program	Loans, grants and loan guarantees for alternative energy and clean energy production projects including electricity generation (except solar), energy efficiency, the renovation/construction of 'High Performance Buildings', research and development facilities, and alternative fuel manufacturing facilities. Applicants are generally required to provide matching funds equivalent to the funding offered under the program. The scheme is open to businesses, economic development organisations, local governments and schools.	Ongoing	http://www.newpa.com/find-and-apply-for-funding/funding-and-program-finder/alternative-and-clean-energy-program
	Pennsylvania	High Performance Building Program	Loans, grants and loan guarantees for construction and renovation projects that achieve certain energy standards for buildings (Gold certification under Leadership in Energy and Environmental Design or the National Green Building Standard, or at least 3 Globes under the GBI Green Globes system). The scheme is open to small businesses (with at most 100 employees) and households. Eligible activities include the acquisition of land or buildings, construction and renovation of buildings, project planning, and verification of building performance.	Ongoing	http://www.newpa.com/sites/default/files/uploads/HighPerformanceBuildingProgram_Guidelines_2009.pdf
	Pennsylvania	Renewable Energy Program - Geothermal and Wind Projects	Loans, grants and loan guarantees for wind and geothermal technologies, including the preparation and installation of generators, and manufacturing facilities for turbines and system compontents. The scheme is open to businesses, economic development organisations, local governments and schools.	Ongoing	http://newpa.com/find-and-apply-for-funding/funding-and-program-finder/renewable-energy-program-geothermal-and-wind-projects
	Pennsylvania	Keystone HELP Energy Efficiency Loan Program	Loans to homeowners for high-efficiency heating, air conditioning, insulation, windows, doors, geothermal heat pumps and 'whole house' improvements. Loans are available to homeowners with a household income of no more than US$150 000.	Ongoing	http://www.keystonehelp.com/index.php
	Pennsylvania	Green Energy Loan Fund	Loans to finance energy conservation and efficiency improvements in buildings. Loans are available to firms, non-profit entities, government entities, and multi-family residential households (but not single-family households). Loans are usually provided for retrofitting measures rather than new construction. Projects must result in a reduction in energy consumption of at least 25 per cent. Loans are usually around US$100 000 to US$2.5 million, with interest rates determined on a case-by-case basis (usually 4 per cent to 6.5 per cent).	Ongoing	http://www.trfund.com/financing/energy/pagelf.html
	Pennsylvania	Small Business Pollution Prevention Assistance Account Loan Program	Low-interest loans to small businesses (with at most 100 full-time employees) for energy efficiency and pollution prevention projects that reduce or re-use raw materials on-site, reduce waste production or significantly reduce energy consumption by the business. Loans are up to 75 per cent of projected costs (up to US$100 000) at a fixed interest rate of 2 per cent.	Ongoing	http://www.portal.state.pa.us/portal/server.pt?open=514&objID=553247&mode=2
Other subsidy or grant	Federal	Bioenergy Program for Advanced Biofuels	Eligible 'advanced biofuel' producers receive payments for the production of fuel from biomass (excluding maize starch). Payment rates differ depending on the feedstocks used, the size of the facility and the total amount of funding available. There are also different payment rates for 'base' production (equal to total production over the previous year) and 'incremental' production (additional production within the year). Available funding was US$55 million in FY 2010.	Ongoing	http://www.rurdev.usda.gov/rbs/busp/9005Biofuels.htm
	Federal	Value-Added Producer Grants	Grants to cover the costs of installing farm-based renewable energy (as well as for other agricultural activities). Eligible participants may apply for either a planning grant or a working capital grant, and there is a limit of 10 per cent of available funding being provided to majority-controlled producer-based business ventures.	Ongoing	http://www.rurdev.usda.gov/rbs/coops/vadg.htm
	Federal	High Energy Cost Grant Program	Grants for improvements in energy generation, transmission and distribution in rural areas, as well as for natural gas or petroleum storage and distribution, renewable energy facilities, backup emergency power generation, and the insulation of of residental properties. 'Communities' with energy costs at least 275 per cent above the national average are eligible to receive grants (which are provided to individuals, non-profit and commerical entities, state and local governments, and tribal governments). Individual grants range from US$75 000 to US$5 million.	Ongoing, although applications have not been accepted since September 2010.	http://www.usda.gov/rus/electric/hecgp/overview.htm or http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US56F&re=1&ee=0
	Federal	Rural Energy for America Program	Loan guarantees and grants to agricultural producers and small rural businesses to purchase renewable energy systems and improve energy efficiency. Projects must occur in a rural area to be eligible. Grants are up to 25 per cent of project costs and are limited to US$500 000 for renewable energy systems and US$250 000 for energy efficiency improvements. Guaranteed loans are for up to 75 per cent of project costs. Available funding was US$86 million in grants and US$10 million in loan guarantee subsidies in FY 2010.	Ongoing	http://www.rurdev.usda.gov/rbs/busp/9006grant.htm http://www.rurdev.usda.gov/rbs/busp/9006loan.htm
	Federal and state	Low Income Home Energy Assistance Program	Block grants provided by the federal government to state governments to provide assistance (mostly financial) to low-income households to pay energy costs and for improving insulation.	Ongoing	http://liheap.ncat.org

Policy type	Jurisdiction	Name	Description	Status and duration	References
	Federal	Conservation Reserve Program	Technical and financial assistance is provided to eligible farmers (to cover annual rental payments and up to 50 per cent of costs) that enter into contracts for soil, water and natural resource management. The scheme encourages farmers to convert environmentally sensitive land to native vegetation, trees, restored land or riparian buffers. Contracts last 10-15 years although landowners retain a right to use land for production again once a contract expires (thus the outcomes might not be permanent). Abatement is expected to occur through sequestration as well as reduced CO2 and nitrogen oxides from field activities and fertilisers. Funding of US$1.8 billion was available in FY 2010.	Ongoing	http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp
	Federal	Conservation Stewardship Program	Financial and technical assistance for the conservation and improvement of soil, water, air, energy, plant and animal life, and other conservation purposes on tribal and private working lands including cropland, grassland, prairie land, improved pasture, and range land, as well as forested land that is an incidental part of an agricultural operation. There is no funding cap, but an annual acreage limitation. Funding of US$390 million was available in FY 2010.	Ongoing	http://www.nrcs.usda.gov/programs/new_csp/csp.html
	Federal	Environmental Quality Incentives Program	Financial assistance for conservation practices on farms. Contracts last for one to ten years and farmers retain the right to use land for produciton again after contracts expire (thus outcomes might not be permanent). Payments are for up to 75 per cent of estimated incurred costs and foregone income from eligible conservation practices and conservation activity plans. Funding of US$1.174 billion was available in FY 2010.	Ongoing	http://www.nrcs.usda.gov/programs/eqip/index.html
	Federal	Wetlands Reserve Program	Voluntary scheme that provides technical and financial support to help landowners protect and restore wetlands on their properties by retiring cropland from agricultural production. Financial assistance can be in the form of a 'permanent easement' (perpetual conservation payment), a '30-year easement' (annual payments of up to 75 per cent of the easement value, and also 75 per cent of restoration costs), and restoration cost-share agreements (up to 75 per cent of restoration costs). Funding of US$630 million was available in FY 2010.	Ongoing	http://www.nrcs.usda.gov/programs/wrp
	Federal	Grassland Reserve Program	Voluntary conservation scheme where participants limit future development and cropping uses of grasslands while retaining the right to conductgrazing operations that are related to the production of forage and seedling (subject to some restrictions). There are both permanent easements and 10-20 year contracts (outcomes might not be permanent in the latter case). Funding of US$100 million was available in FY 2010.	Ongoing	http://www.nrcs.usda.gov/programs/grp
	Federal	Woody Biomass Utilization Grant Program	Support to create markets for small-diameter material and low-value trees that are removed during forest restoration activities (such as fuel-reduction programs to reduce the risk of bushfires) on US Forest Service and 'partner' lands. The aims include reducing forest management costs, creating incentives for the use of woody biomass, implementing projects that remove economic and market barriers to using woody biomass for renewable energy, and the production of renewable energy from woody biomass. Individual grants range from US$50 000 to US$250 000. Funding of US$3.7 million was available in 2011.	Ongoing, but does not appear to be run in all years (for example, the program operated in 2009 and 2011 but not in 2010).	http://www.fs.fed.us/woodybiomass/opportunities.shtml and http://www.fpl.fs.fed.us/research/units/tmu/tmugrants.shtml and http://www.fpl.fs.fed.us/research/units/tmu/tmugrants_eligibility.shtml
	Federal	Standby Support Rule	Government-provided insurance for nuclear energy projects to shield utilities from regulatory and litigation-related delays. This applies to the first six reactors that are built following the enactment of the Energy Policy Act of 2005 (US). The insurance covers costs up to US$500 million for each of the first two reactors, and 50 per cent of costs up to US$250 million for the next four reactors, after an initial 180-day delay.	Ongoing	http://www.ne.doe.gov/pdfFiles/standbySupportFinalRule080406FactSheet.pdf
	Federal	Renewable Energy Deployment Grants	50 per cent grant for the construction of small renewable energy projects with a commercial generation capacity of less than 15 MW (including energy from solar, wind, geothermal, ocean, biomass or landfill gas sources). In January 2010, five projects were selected to receive a total of over US$20.5 million, funded from the American Recovery and Reinvestment Act of 2009 (US).	Ongoing	http://www1.eere.energy.gov/recovery/news_detail.html?news_id=15759
	Federal	Electric Drive Vehicle Battery and Component Manufacturing Initiative	Grants for US-based manufacturers of lithium ion and other 'advanced' batteries and electric drive components, including material and component manufacturing, manufacturing equipment and recycling plants.	Some funds are still being paid to past grant awardees, although additional grants are not currently being provided.	http://www.energy.gov/7749.htm
	Federal	Near-Term Transportation Sector Electricification Program	Grants for conducting qualified electric transportation projects, with priority given to large-scale projects.	Ongoing	
	Federal	Voluntary Airport Low Emission Program	Scheme to reduce ground-based (non-aviation) emissions at commercial service airports that are located in designated 'air quality nonattainment and maintenance areas'. Financial assistance is provided to increase the use of 'alternative fuel' vehicles and other low-emissions technologies. Funding is provided from the Airport Improvement Program and the Passenger Facility Charges program.	Ongoing	http://www.faa.gov/airports/environmental/vale/
	Federal	Geologic Sequestration Training and Research	Grants for projects that provide training to graduate and undergraduate students in areas related to implementing and deploying carbon capture and storage technologies. US$12.7 million has been made available for 43 projects.	Ongoing	http://fossil.energy.gov/recovery/projects/geologic_sequestration_training.html
	Federal	SmartWay Transport Partnership	Grants for projects that reduce diesel emissions (grants are provided through the Clean Diesel Finance Program). There are also grants for certified trailers and tractors, and the retrofitting of emissions-reduction technologies. In addition, SmartWay involves the provision of information, tools and models to transport industries (for example, trucking, rail, shipping) to reduce fuel use and greenhouse gas emissions.	Ongoing	http://www.epa.gov/smartway/basic-information/index.htm http://www.epa.gov/smartway/transport/what-smartway/financing-clean-diesel-info.htm
	Federal, state and local governments (administered at the federal level)	Clean School Bus USA	Public-private and intergovernmental partnerships to reduce diesel emissions from school bus idling, upgrade school buses with emissions-control technologies, upgrade buses to use 'cleaner' fuels, and replcae older buses with newer, lower-emissions buses. Funding is provided to School Districts from a range of sources, including from federal and state governments.	Ongoing	http://www.epa.gov/cleanschoolbus/funding.htm
	State	Clean School Bus schemes	State-level schemes that aim to reduce emissions from school buses.	Ongoing	http://www.afdc.energy.gov/afdc/laws
	State	Heavy Duty Vehicle Emission Reduction grants and loans	Grants provided by state governments for projects that reduce emissions from heavy duty vehicles.	Ongoing	http://www.afdc.energy.gov/afdc/laws

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	State	Alternative Fuel Infrastructure Grants	Funding provided by state governments for 'alternative fuel' vehicles and fuelling infrastructure.	Ongoing	http://www.afdc.energy.gov/afdc/laws
	State	Support for idle-reduction technologies	Various state government policies that aim to reduce idling by trucks. This usually consists of grants or loans for idle-reduction technologies, but in some states also includes direct regulation.	Ongoing	http://www.afdc.energy.gov/afdc/laws
	California	Motor Vehicle Registration Fee Program	Grant funding for projects that reduce air pollution from vehicles, including projects that involve purchasing 'alternative fuel' vehicles or developing 'alternative fuelling' infrastructure. Funds are raised through vehicle registration charges.	Ongoing	http://www.arb.ca.gov/planning/tsaq/mvrfp/mvrfp.htm and http://www.afdc.energy.gov/afdc/laws/law/CA/6132
	California	Hybrid Truck and Bus Voucher Incentive Project	Vouchers provided to owners of fleets that operate in California for the purchase of medium and heavy-duty hybrid-electric vehicles (trucks or buses). Vouchers range from US$10 000 to US$30 000 and are expected to cover half the incremental cost of a hybrid heavy-duty vehicle (that is, the cost difference compared to a conventional vehicle). Around US$15 million in funds is available in 2011.	Ongoing	http://www.californiahvip.org
	Illinois	Biogas and Biomass to Energy Grant Program	Grants for projects that use biogas or biomass as a fuel source for electricity production and combined heat and power, through gasification, co-firing or anaerobic digestion technologies. Grants cover 50 per cent of the cost of feasibility studies (with a maximum grant of US$2500) or the installation of equipment (maximum of US$225 000 for biogas and US$500 000 for biomass). The scheme is funded from the Renewable Energy Resources Trust Fund (public benefit fund).	Ongoing	http://www.commerce.state.il.us/dceo/Bureaus/Energy_Recycling/Energy/Clean+Energy/02-BiogasBioMass.htm
	Illinois	Clean Energy Community Foundation Grants	Grants are provided for projects that improve energy efficiency, develop renewable energy, or preserve natural areas in Illinois. Grants are to non-profit organisations, local governments or schools (under the Solar Schools Program). The total endowment for the fund (from which grants are paid) is US$225 million.	Ongoing	http://www.illinoiscleanenergy.org/how-to-apply/
	Illinois	Energy Efficient Affordable Housing Construction Program	Grants to housing developers that are based in Illinois to fund energy-efficient building practices in the construction of 'affordable' housing units (including renovations). Projects must be targeted at houses that meet low- and moderate-income criteria (150 per cent of poverty level). Energy efficiency standards must be met to obtain a grant. Grants vary depending on the size of the building and whether it is new or renovated.	Ongoing	http://www.illinoisbiz.biz/dceo/Bureaus/Energy_Recycling/Energy/Energy+Efficiency/housing_energy_program.htm http://www.illinoisbiz.biz/NR/rdonlyres/BA212AA5-84F4-4796-A768-ABC50986B5BB/0/benefits2006.pdf
	Illinois	Biofuels Production Facility Grants	Grants for the production or expansion of ethanol and biodiesel production facilities of at least 5 million gallons per year. Grants are for the lesser of 10 per cent of total construction costs or US$4 million.	Ongoing	http://www.afdc.energy.gov/afdc/laws/law/IL/6484
	Illinois	Public Sector Electric Efficiency	Grants (including rebates) for government agencies (local, state and federal), public school districts, community colleges and universities for energy efficiency improvements in lighting, refrigeration, heating and air conditioning. Grants are only available to eligible entities that purchase electricity from Commonwealth Edison or Ameren affiliated utilities. Rebates and grants vary by technology, with a maximum of: US$300 000, or 75 per cent of project costs, or 100 per cent of incremental costs. Rebates are provided for amounts of US$50 000 or less, and grants for larger amounts.	Ongoing	http://www.illinoisbiz.biz/dceo/Bureaus/Energy_Recycling/Energy/Energy+Efficiency/
	Pennsylvania	Pennsylvania Energy Development Authority grants	Grants for 'clean, advanced energy' projects in Pennsylvania, including 'alternative fuels' for transport, solar energy, wind, hydropower, geothermal, methane from biological sources, biomass, fuel cells, coal-mine methane, waste coal, integrated gasification combined cycle and energy efficiency. Grants are usually provided to cover capital costs. The maximum grant amount for a project is US$1 million. US$16 million in grants was available in 2010.	Ongoing	http://www.portal.state.pa.us/portal/server.pt/community/pedamove_to_grants/10496 http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=PA16F&re=1&ee=1
	Pennsylvania	High Performance Green Schools Planning Grants	Grants for schools to cover costs that are incurred when building 'green' rated buildings rather than conventional buildings. Grants are usually for US$25 000 and cover simulation and modelling costs, consultancy fees, and costs involved in attaining 'green' certification.	Ongoing	http://www.portal.state.pa.us/portal/server.pt/community/schools/13838/funding_opportunities/588215
	Pennsylvania	Biodiesel Production Refund	A payment of US$0.75 per gallon for commercial biodiesel producers with a capacity of at least 25 000 gallons, up to a maximum of US$1.9 million in a fiscal year.	Set to expire 30 June 2011.	http://www.afdc.energy.gov/afdc/laws/law/PA/6480
Fuel or resource tax	Federal	Federal fuel excise	Federal-level excise rates are US$0.18/gallon (US$0.05/L) of petrol, US$0.24/gallon (US$0.06/L) of diesel and US$0.14/gallon (US$0.04/L) of LPG.	Ongoing	http://www.fhwa.dot.gov/policyinformation/motorfuelhwy_trustfund.cfm
	State	State fuel excises	Fuel tax rates and tax systems differ significantly across states. State taxes averaged around US$0.21/gallon (US$0.06/L) of petrol and diesel, and US$0.10/gallon (US$0.03/L) of LPG in 2010.	Ongoing	http://www.fhwa.dot.gov/policyinformation/motorfuelhwy_trustfund.cfm
Other tax	Federal	Heavy Vehicle Use Tax	This tax is levied on heavy vehicles of gross weight 55 000 pounds (24 948 kg) or greater that operate on public highways. The maximum tax rate is US$550 per year and applies to vehicles over 75 000 pounds (34 019 kg). For vehicles of lesser weight, the tax rate is US$100 plus US$22 for every 1000 pounds over the 55 000 pound level. Government agencies (federal, state, local and tribal) and some emergency services are exempt from the tax.	Ongoing	http://www.fhwa.dot.gov/policy/091116/pdfs/fhwa8-page.pdf
	Federal	Gas Guzzler Tax	Tax on vehicles that have a fuel efficiency rating of 22.5 miles per gallon (mpg) or less. There are different tax rates depending on the amount by which fuel efficiency is less than 22.5 mpg. The tax applies to domestically produced and imported vehicles that weigh 6 000 pounds (2 722 kg) or less (vans, trucks and sports utility vehicles are excluded). In practice, the tax is mostly paid on luxury and sports cars.	Ongoing	http://www.epa.gov/fueleconomy/guzzler/index.htm
Regulatory instruments					

Policy type	Jurisdiction	Name	Description	Status and duration	References
Renewable energy certificate scheme	Arizona, California, Colorado, Connecticut, Delaware, Florida, Hawaii, Illinois, Iowa, Kansas, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, Texas, Washington, West Virginia, Wisconsin, District of Columbia.	Renewable Portfolio Standards (RPSs)	Mandatory renewable energy targets (most of which have renewable energy certificates) exist in 36 states and the District of Columbia, with voluntary schemes in an additional five states. The design of these schemes, and the renewable technologies supported, differ across states. All schemes cover wind, solar PV, hydroelectricity, biomass, biofuels and landfill gas. Obligations are placed on generators in some states, and on retailers in others. 'Alternative compliance payments' exist in some states, a penalty paid per unit of non-compliance (in effect a price cap).	Ongoing	http://www.epa.gov/chp/state-policy/renewable_fs.html http://www.pewclimate.org/what_s_being_done/in_the_states/rps.cfm
Electricity supply or pricing regulation	Federal	Public Utility Regulatory Policies Act	The Public Utility Regulatory Policies Act of 1978 (US) requires utilities to purchase electricity generated from small renewables-based electricity producers (below 80 MW capacity) at avoided cost rates.	Ongoing	http://www.oe.energy.gov/purpa.htm
	California, Illinois, Montana, Oregon, Washington (plus New Mexico from 2017).	Emissions and carbon capture standards for power plants	Some states have imposed an emissions intensity limit on new power plants (for example, emissions per MWh). In California, Oregon, Washington and New Mexico, the limit is 1100 pounds (499 kg) of CO2 per MWh (with the limit in New Mexico scheduled to be implemented in 2017). In Illinois, 50 per cent of CO2 must be captured and sequestered from 2009 (with the percentage increasing over time). A similar requirement is in place in Montana (which applies to existing as well as new plants). In Oregon and Washington, new power plants are also required to offset a portion of anticipated CO2 emissions (reducing emissions on their own or paying a fee to an organisation that selects and funds offset projects). In Massachusets and New Hampshire, existing power plants must reduce their emissions of CO2 to a particular level.	Ongoing	http://www.pewclimate.org/publications/report/coal-initiative-series-performance-standards-approach-reducing-co2-emissions-ele
	State	Net metering	Net metering policies allow electricity users (for example, households) that also generate some of their own electricity to offset consumption over a billing period by providing their excess generation back to the grid. Customers receive retail prices for the excess electricity they generate (rather than a lower rate on a separate meter, as usually occurs without net metering). In some states, customers can choose between these payments and Renewable Energy Certificates for their electricity production. Net metering is used in 44 states: statewide for all utilities in 18 states; statewide for certain utility types in 23 states; and for individual utilities in 3 states.	Ongoing	http://apps3.eere.energy.gov/greenpower/markets/netmetering.shtml http://www.dsireusa.org/summarytables/rrpre.cfm
	Federal and state	Interconnection Standards	Interconnection standards for distributed generation at a customer's point of delivery, usually with limits on capacity and voltage. These can include some concessions, such as discounted pre-interconnection study fees for small units. These can support distributed renewable generation on the grid. Most standards are set at the state level, although some are also implemented by the Federal Energy Regulatory Commission for utilities that are under its jurisdiction.	Ongoing	http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CA21R&re=1&ee=0 http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US06R&re=1&ee=0
Technology standard	Federal	Corporate Average Fuel Economy (CAFE)	Fuel efficiency standards for light-duty vehicles (passenger cars and light trucks with a gross vehicle weight rating of 8500 pounds (3856 kg) or less). For model year 2011, the standards are 31.2 miles per gallon (mpg) for passenger cars and 25.0 mpg for light trucks (standards have become more stringent each year). Standards are reduced for 'alternative fuel' vehicles. Standards apply over each manufacturer's fleet, and thus manufacturers can average out fuel efficiency over the range of models they produce (credits can also be traded between manufacturers). From 2012 onwards, standards are set in terms of grams of greenhouse gas emissions per mile travelled (standards are 263 g CO2/mile for passenger cars and 346 g CO2/mile for light trucks in 2012).	Ongoing	http://www.nhtsa.gov/fuel-economy http://epa.gov/otaq/climate/regulations/420f10038.pdf http://www.epa.gov/oms/climate/regulations/420f10014.htm
	Federal	Heavy Duty National Program	Fuel efficiency and greenhouse gas standards have been proposed for medium-duty and heavy-duty vehicles (with a gross vehicle weight rating of 8500 pounds (3856 kg) or greater) from model year 2014. The standards vary by the type of vehicle and cover combination tractors, heavy-duty pickup trucks and vans, and vocational vehicles (including buses).	Committed; regulations to apply from 2014.	http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/CAFE_2014-18_Trucks_FactSheet-v1.pdf
	Arizona, California, Connecticut, Florida, Massachusetts, Maine, Maryland, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Rhode Island, Vermont, Washington, District of Columbia.	California Vehicle Emissions Standards	California sets vehicle emissions standards that are higher than federal regulations (due to a waiver under the Clean Air Act, it is the only state that can do so, and other states can choose to follow the Californian or federal standards). The standards apply to passenger cars, light-duty trucks and medium-duty vehicles. New vehicles are required to achieve a 30 per cent reduction, on average, in greenhouse gas emissions by 2016. California and those states that have adopted the Californian regulation have agreed to conform to the federal standard from 2012 to 2016. However, in 2009 a federal executive order committed to matching California's standards after 2016.	Ongoing	http://www.arb.ca.gov/msprog/levprog/levprog.htm http://www.pewclimate.org/what_s_being_done/in_the_states/vehicle_ghg_standard-moreinfo.cfm
	California	Zero Emission Vehicle Production Requirements	Vehicle manufacturers in California must produce and deliver for sale in California a minimum percentage of zero-emission vehicles (certified to produce no exhaust emissions of any criteria pollutant) each model year. The requirement for model year 2011 was 11 per cent. Manufacturers receive credits for zero-emission vehicles they produce, which can be banked or traded.	Ongoing	http://www.arb.ca.gov/msprog/zevprog/zevprog.htm http://www.arb.ca.gov/msprog/zevprog/zevcredits/zevcredits.htm

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Fuel content mandate	Federal	Federal Renewable Fuel Standard (RFS)	The federal RFS sets the minimum volume of biofuels that must be sold each year. In 2011 the minimum volumes are 13.95 billion gallons (52.81 billion litres) of biofuel, which is equivalent to a mandate of 8.01 per cent biofuel to be contained in conventional fuels (petrol or diesel). Of this, 0.78 percentage points must consist of 'advanced biofuels' (that is, not maize starch), and within the advanced biofuel category 0.69 percentage points must be biomass-based diesel and 0.003 percentage points must be cellulosic biofuel. Most biofuel must also meet emissions reduction criteria to be used for scheme compliance. Fuel suppliers can meet the requirements of the scheme through the creation of Renewable Identification Number certificates, which are tradable.	Ongoing	http://www.epa.gov/otaq/fuels/renewablefuels/index.htm http://www.epa.gov/otaq/fuels/renewablefuels/420f10043.htm
	Florida, Hawaii, Iowa, Louisiana, Massachusetts, Minnesota, Missouri, Montana, New Mexico, Oregon, Pennsylvania, Washington.	State Renewable Fuel Standards	A required percentage of renewable fuel (for example, ethanol or biodiesel) in gasoline and diesel sold. In some states, the RFS does not apply until a certain volume of biofuel production or consumption has been reached.	Ongoing	
	State (in place in California and proposed for 23 states, including Oregon, Washington, 9 midwestern states and 11 north-eastern states).	Low Carbon Fuel Standards (LCFS)	Standards for the maximum amount of carbon that can be contained in a given volume of vehicle fuel, or emitted during the manufacture, transport and use of that fuel. Standards are usually expressed in terms of emissions per unit of fuel energy. In most proposed schemes, fuel providers are also required to reduce their average fuel carbon intensity by a given percentage, and can use tradable (and bankable) credits to do so. Currently a scheme is in place only in California but other states are developing or implementing similar schemes.	Ongoing in California; committed in other states.	http://www.pewclimate.org/what_s_being_done/in_the_states/low_carbon_fuel_standard http://www.arb.ca.gov/fuels/lcfs/lcfs.htm
	California	California Low Carbon Fuel Standard	The California LCFS came into effect in January 2011, with the aim of reducing the average emissions-intensity of all transport fuels sold in California by 10 per cent by 2020 (relative to 2010 levels). It specifies that in 2011 the average emissions-intensity of petrol (and its substitutes, such as ethanol) sold cannot exceed 95.61 grams of CO2e per megajoule (MJ). For diesel (and its substitutes, such as biodiesel), the limit is 94.47 g CO2e/MJ.	Ongoing	http://www.arb.ca.gov/regact/2009/lcfs09/lcfscombofinal.pdf
Energy efficiency regulation	Federal and state	Weatherization Assistance Program	Funding for low-income households to improve the energy efficiency of their dwellings. Technical and financial assistance is provided to support residential energy retrofitting programs run by state and local Weatherization Agencies. Funding in FY 2010 was US$228 million.	Ongoing	http://www1.eere.energy.gov/wip/wap.html
	Federal	Appliances and Commercial Equipment Standards	Minimum efficiency standards for residential appliances and commercial equipment. Residential products include battery chargers, external power supplies, central air conditioners, heat pumps, clothes washers and dryers, direct heating equipment, furnaces and boilers, fluorescent lamp ballasts, high-intensity discharge lamps, pool heaters, microwave ovens, refrigerators and freezers, room air conditioners, and water heaters. Commercial equipment includes clothes washers, distribution transformers, electric motors, furnaces and boilers, high-intensity discharge lamps, metal halide lamp fixtures, and walk-in coolers and freezers. This scheme also includes the phase out of incandescent light bulbs by 2015, and the phase out of less efficient fluorescent tubes.	Ongoing	http://www1.eere.energy.gov/buildings/appliance_standards/index.html
	Arizona, California, Colorado, Connecticut, Florida, Hawaii, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Nevada, New Mexico, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, Texas, Vermont, Virginia, Washington.	Energy Efficiency Resource Standards	State-based schemes that require electricity and natural gas utilities to reduce energy use by a specified and increasing amount (or percentage) each year by offering programs or payments to residential and industrial customers to reduce their energy use (these schemes are sometimes called Energy Efficiency Portfolio Standards). Schemes are in place in 24 states with an additional four having committed to introduce such a scheme. Some states have tradable energy savings certificates (white certificates), and some include improvements in electricity distribution, combined heat and power, and other technologies. 'Alternative compliance payments' exist in some states, a penalty paid per unit of non-compliance.	Ongoing	http://www1.eere.energy.gov/industry/states/pdfs/eers_web_final.pdf http://www.aceee.org/research-report/e063 http://www.pewclimate.org/what_s_being_done/in_the_states/efficiency_resource.cfm
	State	State Building Codes	All US states have mandatory building codes which typically include minimum standards for heating, cooling and/or energy efficiency in new residential and/or commercial buildings. Often, these standards are developed from a version of the International Energy Conservation Code. In some states, codes include specific minimum technologies (building products) or the compulsory disclosure of building energy usage and efficiency ratings to potential buyers or renters. In addition, the federal Department of Energy provides assistance to states to develop codes through the Building Energy Codes Program.	Ongoing	http://www.energycodes.gov/about
	California	Appliance Efficiency Regulations	Minimum efficiency standards for audio-video products, clothes washers, pool pumps, incandescent bulbs, water dispensers, hot tubs, commercial hot food cabinets, cabinet fluorescent lamps, vending machines, and televisions.	Ongoing	http://www.energy.ca.gov/appliances/index.html
	California	Fuel-Efficient Tire Program	An energy efficiency program for the replacement of tyres on passenger cars and light-duty trucks, involving minimum efficiency standards and an information program.	This scheme has been established in legislation, although it is unclear whether it has commenced operation.	http://www.energy.ca.gov/tires/index.html

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
Synthetic greenhouse gas regulation	Federal	Significant New Alternatives Policy Program	The evaluation and regulation of substitutes for ozone-depleting substances (several of which are high-GWP greenhouse gases) that are being phased out under the Clean Air Act. The scheme involves the review of substitutes for various industrial sectors, including refrigeration, air conditioning, solvents, fire suppression and aerosols.	Ongoing	
Urban or transport planning regulation	Federal	Energy Development Programs	A scheme to identify public lands with potential for renewable energy development (solar, wind and geothermal), and to expedite the processing and permitting of some renewable energy projects on the National System of Public Lands. Around US$41 million in funding under the American Recovery and Reinvestment Act of 2009 (US) has been used to support 65 projects.	Ongoing	
	Federal	Final Rule on Renewable Energy and Alternate Uses of Existing Facilities on the Outer Continental Shelf	A program that grants leases, easements and rights-of-way for renewable energy activities on the outer continental shelf (for example, the siting and construction of off-shore wind farms). There are also provisions for sharing revenues from such projects with adjacent coastal states.	Ongoing	
	Federal	Smart from the Start Initiative	Support for the establishment of wind farms in designated sites on the outer continential shelf, including through cooridnated environmental studies, large-scale planning and expedited approval processes.	Ongoing	
	State	High Occupancy Vehicle Lane use	In some states, low-emissions vehicles are permitted to use high-occupancy vehicle lanes with only one person in the car. Low-emissions vehicles include compressed natural gas, hydrogen, electric, hybrid electric and plug-in hybrid electric vehicles.	Ongoing	
Other regulation	Federal	Mandatory Reporting of Greenhouse Gases Rule	All greenhouse gas emissions must be reported to the Environmental Protection Agency by suppliers of fossil fuels or industrial greenhouse gases, manufacturers of vehicles and engines, facilities that inject carbon dioxide underground, and 25 types of facilities with emissions over 25 000 metric tonnes per year.	Ongoing	http://www.epa.gov/climatechange/emissions/ghgrulemaking.html
	Federal	New Source Review and Title V permitting requirements for greenhouse gases	Under the Clean Air Act, permits must be obtained for the construction and operation of stationary sources of air pollution. The type of permits that are required depend on whether a facility is located in an 'air quality attainment' area or not. In addition, facilities in attainment areas must install the 'best available control technology' to reduce air pollution (with the technology generally determined on a case-by-case basis). Facilities in non-attainment areas must meet the 'lowest achievable emissions rate'. Since January 2011, these requirements have covered greenhouse gas emissions from sources that meet a specified emissions threshold, although implementation is being phased in.	Ongoing	http://www.epa.gov/apti/course422/apc4d.html http://www.epa.gov/nsr/ghgdocs/ghgpermittingtoolsfs.pdf http://www.epa.gov/nsr/documents/20100413fs.pdf
	Federal	New Source Performance Standards	Greenhouse gas emissions standards have been proposed for all entities that emit above a specified threshold. Standards are currently being developed for fossil fuel power plants and petroleum refineries, with draft standards scheduled for release in July 2011, and finalisation in May 2012 (with corresponding dates of December 2011 and November 2012 for refineries). Performance standards for existing plants and refineries may follow at a later stage.	Committed.	http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/d2f038e9daed78de8525780200568bec!OpenDocument
	Federal	Price-Anderson Act	Indemnification of civilian nuclear reactor operators from claims relating to accidents. Reactor licencees are required to obtain the maximum amount of insurance against nuclear-related accidents (currently around US$375 million per plant), and any monetary claims within this amount are paid by the insurer. For larger claims, the Price-Anderson fund is used, into which reactor operators are required to contribute in the event of an accident. The maximum amount of the fund is around US$11.6 billion (the maximum contribution by an individual operator is US$111.9 million in the event of an accident, and capped at US$17.5 million in one year). Any remaining liabilitity costs then become the responsibility of the federal government.	Ongoing	http://www.nei.org/resourcesandstats/documentlibrary/safetyandsecurity/factsheet/priceandersonact/
	Federal	New Source Performance Standards Municipal Solid Waste Landfills Rule	Municipal solid waste landfills with landfill gas emissions (primarily methane) over 50 tonnes per year must capture and combust these emissions.	Ongoing	http://www.epa.gov/ttn/atw/landfill/landflpg.html http://www.epa.gov/ttn/atw/landfill/app_a.pdf
	California	Tire Inflation Regulation	Automotive service providers are required to check and inflate each vehicle's tyres to the recommended tyre pressure rating each time they undertake maintenance or repair services for a vehicle.	Ongoing	http://www.arb.ca.gov/cc/tire-pressure/tire-pressure.htm
Direct government expenditure					
Government procurement - general	Federal	Federal Fleet Management Guidance	Federal government agencies with 20 or more vehicles must reduce their annual consumption of petroleum-derived products by 2 per cent, relative to a 2005 baseline. In addition, agencies must increase their consumption of 'alternative fuels' (including biofuels) by 10 per cent each year until 2015 (relative to 2005).	Ongoing	http://www1.eere.energy.gov/femp/program/fedfleet_requirements.html http://www1.eere.energy.gov/femp/pdfs/fleetguidance_13514.pdf
	Federal	Green Power Purchasing	New federal government buildings are required to meet targets for the proportion of electricity consumption that comes from renewable sources. The minima are 3 per cent for FY 2007 to FY 2009, 5 per cent for FY 2010 to FY 2012, and 7.5 per cent for FY 2013 onwards (with exemptions in some circumstances). In addition, at least half of the renewable energy consumed must be from sources placed into service after 1 January 1999.	Ongoing	http://www1.eere.energy.gov/femp/regulations/requirements_by_subject.html
	Federal	Federal Building Energy Efficiency Performance Standards	Energy efficiency requirements for federal government buildings. The goal is to reduce energy use to 30 per cent below the fiscal year (FY) 2003 level by FY 2015. The target for FY 2010 is a 15 per cent reduction. New buildings must be 30 per cent below American Society of Heating, Refrigerating and Air-Conditioning Engineers or International Energy Conservation Code standards and obtain 30 per cent of their hot water from solar heating (if this is life-cycle cost effective).	Ongoing	http://www1.eere.energy.gov/femp/regulations/requirements_by_subject.html
	Federal	Alternative Fuel Vehicles fleet requirements	75 per cent of new light-duty vehicles acquired by some federal government agencies must be 'alternative fuel vehicles' that weigh less than 8500 pounds (3856 kg) (this includes hybrid electric vehicles, fuel cell vehicles and advanced lean burn vehicles). Compliance can be achieved using credits, which are earned for purchasing certain vehicle types or for the use of biodiesel.	Ongoing	http://www1.eere.energy.gov/femp/program/fedfleet_requirements.html

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	Federal	Energy Savings Performance Contracts	Contracts between private-sector energy service companies and federal government agencies whereby the energy service company is contracted to design, purchase and install equipment and processes that increase energy efficiency. Federal agencies pay the contractor a share of the cost savings that are expected to be accrued over the life of the contract. Contractors are only paid if actual savings result from reduced energy use.	Ongoing	http://www.epa.gov/oaintrnt/energy/espc.htm http://www1.eere.energy.gov/femp/financing/espcs.html
	Federal	Green Purchasing Affirmative Procurement Program	Procurement scheme for the Department of Agriculture that sets guidelines for, and promotes, the purchase of recycled-content products, biobased products, energy-efficient products (including those with Energy STAR ratings), 'alternative' fuels and other goods and services.	Ongoing	http://www.dm.usda.gov/energyandenvironment/greenpurchasing/index.html
	Federal	Energy Efficient Retrofits	Funding for energy efficiency retrofits at the Bureau of Land Management, Fish and Wildlife Service and National Park Service.	Ongoing	
	Federal	Energy Conservation Investment Program	Scheme to improve the energy and water efficiency of military facilities by increasing investment in energy conservation and energy efficient technology. Funding for FY 2011 is US$124 million.	Ongoing	http://www.acq.osd.mil/ie/energy/ecip/ecip.shtml
	State	State Energy Standards for Public Buildings	Some states have energy efficiency standards for state government buildings, such as a minimum requirement in terms of Leadership in Energy and Environmental Design or Green Globes standards. In some states, there are requirements for including energy efficiency components in new buildings or renovations, or targets for reducing energy use by a particular date (for example, in California).	Ongoing	http://www.pewclimate.org/sites/default/modules/usmap/pdf.php?file=5888
	State	Alternative Fuel Vehicles fleet requirements	State government requirements for the proportion of 'alternative fuel vehicles' in state government fleets.	Ongoing	http://www.afdc.energy.gov/afdc/laws
	Pennsylvania	Green Power Purchasing	The state government has a target of purchasing of 50 per cent of its electricity from wind and biomass generation each year.	Ongoing	http://www.portal.state.pa.us/portal/server.pt/community/green_energy/13833/green_electricity_in_pa/588175
	Pennsylvania	Executive Order 2004-12	Energy management and conservation activities, including the development of standards for new construction and renovation, training personnel in life-cycle cost analysis, developing procedures and standards, and procuring energy efficient products.	Ongoing	http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=PA12R&re=0&ee=1
Government investment - infrastructure	Federal	High-speed rail	A goal to expand high-speed intercity passenger rail capacity over the next 25 years, to give 80 per cent of the population access to high-speed rail services. This is expected to involve a capacity expansion equivalent to 1900 miles (3 058 km) of highway. Some funding has already been distributed to state governments. Proposed spending for 2011 to 2017 is US$53 billion. US$8 billion has already been provided to 31 states.	Committed. Some funding has already been provided.	http://www.whitehouse.gov/blog/2011/02/08/bringing-high-speed-rail-america
	Federal	Next Generation Air Transportation System	Changes to the national airspace management system that tracks air traffic to improve the precision of tracking and reduce fuel use, noise and pollution. Around US$85 million in funding was available in FY 2010.	Ongoing	
Support for research and development					
R&D - general and demonstration	Federal	Solar Energy Technologies Program	Research, development, demonstration and deployment scheme for solar PV technologies, including for sub-programs: Photovoltaics (research and development for solar PV), Concentrating Solar Power (partnerships between firms, universities and national laboratories to reduce system and energy storage costs), Systems Integration (funding for demonstrating new technologies and developing standards), and Market Transformation (information provision and standard setting). In addition, the scheme also provides funding for the Solar America Board for Codes and Standards (which establishes standards for solar energy technologies), Solar America Communities (funding for local governments to adopt solar energy) and Solar America Showcases (technical assistance for large-scale solar installations).	Ongoing	http://www1.eere.energy.gov/solar/
	Federal	Geothermal Technologies Program	Research, development and deployment scheme for geothermal technologies. The components of the scheme provide support for: Enhanced Geothermal Systems, Hydrothermal Power Generation, Low-Temperature and Co-produced Geothermal Resources, Geothermal Strategic Planning and Analysis and Technology Validation. In addition, scheme includes partnerships with industry. Funding was US$44 million in FY 2010.	Ongoing	http://www1.eere.energy.gov/geothermal/
	Federal	Biomass Program	Research, development and deployment scheme for biomass feedstock development; logistics, processing and transport; increasing the efficiency of biofuels (biochemical and thermochemical conversion); improving 'sustainability'; and strategic and portfolio analysis. US$220 million in funding was available in FY 2010.	Ongoing	http://www1.eere.energy.gov/biomass/
	Federal	Wind & Water Power Program	Research, development and deployment scheme for wind and water energy research, involving partnerships and cost-sharing with industry and other government agencies. The scheme includes research and development projects for large wind turbine technology and grid interconnection, as well as the Wind Powering America educational program and Federal Wind Siting Information Center. Support for hydro, wave and tidal energy includes technology development, support for siting generators and the Marine and Hydrokinetic Technology and Hydrodynamic Testing Facilities databases. $130 million in funding was available in FY 2010.	Ongoing	http://www1.eere.energy.gov/windandhydro/
	Federal	Fuel Cell Technologies Program & Hydrogen Program	Research, development, demonstration and deployment scheme for fuel cells and hydrogen in the stationary energy and transport sectors, involving partnerships with the private sector and universities. Research includes overcoming technical barriers to hydrogen production, delivery and storage; the development of fuel cell technologies; and the validation and demonstration of hydrogen and fuel cells. This includes the National Hydrogen Learning Demonstration, a partnership between government and industry to test and demonstrate hydrogen fuel cell vehicles and infrastructure. Funding was US$174 million in FY 2010.	Ongoing	http://www1.eere.energy.gov/hydrogenandfuelcells http://www.hydrogen.energy.gov http://www.hydrogen.energy.gov/annual_progress10.html
	Federal	Energy Storage Program	Research and development for energy storage technologies and systems that incorporate a broad technology base consisting of batteries (both conventional and advanced), flywheels, high-energy-density capacitors, superconducting magnetic energy storage, power electronics, and control systems. The scheme involves partnerships with industry and cost-sharing of projects. US$13.6 million in funding was available in FY 2010.	Ongoing	
	Federal	Commercial Aviation Alternative Fuels Initative	Research and development scheme run by a coalition of airlines, aircraft manufacturers, energy producers and US government agencies. The scheme mainly promotes the development of alternative jet fuels.	Ongoing	http://www.caafi.org/
	Federal	Clean Automotive Technology	A scheme that develops engine and drivetrain technologies, for cars and trucks, to reduce greenhouse gas and particulate emissions and increase fuel efficiency. This includes partnerships with industry and cost-sharing of projects.	Ongoing	http://www.epa.gov/otaq/technology/

Policy type	Jurisdiction	Name	Description	Status and duration	References
	Federal	Innovations for Existing Plants	Research, development and deployment scheme for carbon capture and storage technologies that can be retrofitted to existing coal-fired power plants, with a focus on existing pulverised coal-fired plants. The aim is to achieve 90 per cent capture of CO2 with at most a 35 per cent increase in electricity costs. US$52 million in funding was available in FY 2010.	Ongoing	http://www.fossil.energy.gov/programs/powersystems/pollutioncontrols http://www.fossil.energy.gov/news/techlines/2008/08030-CO2_Capture_Projects_Selected.html
	Federal	Carbon Sequestration Program	Research, development and demonstration scheme for technologies that capture and permanently store greenhouse gases. This includes demonstrations of CO2 measurement and detection technologies at sequestration sites and partnerships with industry to develop particular technologies. US$154 million in funding was available in FY 2010.	Ongoing	http://fossil.energy.gov/programs/sequestration/index.html
	Federal	Carbon Sequestration Regional Partnerships	Assistance to develop technology, infrastructure and regulations to implement large-scale carbon capture and storage projects in different regions and geological areas of the United States. This involves participation by local organisations and individuals in each region.	Ongoing	
	Federal	Solid-State Lighting Program	A scheme that facilitates the development of energy-efficient white light sources for general illumination, including research and development activities, commercialisation, standards development, information provision and industry partnerships. US$19.2 millionin funding was provided in FY 2010.	Ongoing	http://www1.eere.energy.gov/buildings/ssl/index.html
	Federal	Small Business Innovation Research Program and Small Business Technology Transfer Program	Grants to small advanced technology firms for the development of energy-related technologies, including funding for the start up and development stages of these firms. Under this scheme, eleven federal government agencies are required to reserve a portion of research and development funds for awards to small businesses.	Ongoing	http://www1.eere.energy.gov/office_eere/pdfs/sbir_program_information_sheet.pdf http://www1.eere.energy.gov/office_eere/sbir.html
	Federal	Advanced Energy Research Projects Agency - Energy (ARPA-E)	Funding for projects that reduce US dependence on energy imports, reduce energy-related emissions (including greenhouse gases), improve energy efficiency, and support the development and deployment of advanced energy technologies. Projects include vehicle technologies, biomass energy and energy storage.	Ongoing	http://arpa-e.energy.gov
	Federal	Biomass Research and Development Initiative	Grant funding for projects related to the research, development and demonstration of biofuels and biomass projects. The focus is on feedstock development, product development and biofuel development analysis. Grants of up to US$1 million are available to tertiary education institutions, national laboratories, federal research agencies, nonprofit organisations, and some private sector entities. At least 20 per cent of project costs must be funded by an entity that is not part of the federal government.	Ongoing	http://www.afdc.energy.gov/afdc/laws/laws/US/incentive/3233
	Federal	Office of Climate Change Policy and Technology	An office within the Department of Energy that coordinates US federal government investment (across multiple agencies) in climate-related research, development, demonstration and deployment. US$9.3 million in funding was received in FY 2010.	Ongoing	http://www.iea.org/textbase/pm/?mode=cc&id=2164&action=detail http://www.climatetechnology.gov
	Federal	National Fuel Cell Bus Program	Research and development scheme to develop commercially viable fuel cell bus technologies and related infrastructure. There is a competitive grants process, with priority given to applicants that have managed 'advanced transportation technology projects' for at least five years. At least 50 per cent of costs must be covered by entities other than federal government agencies.	Ongoing	http://www.fta.dot.gov/funding/grants/grants_financing_3695.html
	Federal	Fuel Cycle Research and Development	Research on nuclear fuel recycling and waste management, funded by the Nuclear Energy Research Initiative of the Department of Energy.	Ongoing	http://www.ne.doe.gov/fuelcycle/neFuelCycle.html
	Federal	Gen IV Nuclear Energy Systems	Research scheme for the development of 'Generation IV' nuclear generation technologies, such as those that can use recycled reactor fuels.	Ongoing	http://www.ne.doe.gov/genIV/neGenIV1.html
	Federal	Building America	A public-private partnership that aims to reduce residential building energy use by 30 to 90 per cent compared to 'typical' construction. The program involves research to assist with the design, construction and evaluation of energy-efficient houses without a large rise in construction costs.	Ongoing	http://www1.eere.energy.gov/buildings/building_america/
	Federal	Bioenergy Research Centers	Three research institutes that were created to undertake research in the development of cellulosic ethanol and other biofuels. These include involvement by national laboratories, universities, private companies and non-profit organisations. Funding was US$75 million in FY 2010.	Ongoing	http://genomicscience.energy.gov/centers
	Federal	Fusion Energy Sciences Program	Basic research into plasma science, fusion science and fusion technology to develop new fusion energy (nuclear energy) technologies.	Ongoing	http://www.er.doe.gov/ofes
	Federal	Joint Global Change Research Institute	A government-funded research organisation that focuses on global climate change and mitigation, and develops opportunities to train university students in interdisciplinary areas. It involves collaboration within the United States and internationally. Research includes integrated assessment modelling, technological strategies, natural resource modelling, adaptation studies, and the development of mitigation measures.	Ongoing	http://www.globalchange.umd.edu
	Federal	Bright Tomorrow Lighting Prizes	Prizes awarded by the Department of Energy for the devleopment of solid state light emitting diodes that meet energy efficiency targets. There are prizes to develop a solid state replacement for a 60 watt incandescent lamp and a solid state replacement for a Parabolic Aluminized Reflector Type 38 Halogen Lamp. The Department of Energy is required to develop guidelines for federal government purchases of the winning products after prizes are awarded.	Ongoing	http://lightingprize.org
	Federal	H-Prize	A US$1 million prize for research into 'advanced' materials for hydrogen storage (based on specific criteria for vehicles). The first prize is to be awarded in 2011, with up to four additional awards in each future year.	Ongoing	http://hydrogenprize.org
	Federal	Solid State Energy Conversion Alliance	Research and development scheme that aims to produce a solid-state fuel cell module (greater than 250 MW) that would have a cost of at most US$400 per kW to manufacture. The scheme covers fuel cell design, strategies for market penetration, and strategies to address hardware problems. It is a collaboration between US national laboratories, universities, small businesses and other research and development organisations. This program received US$50 million in funding in FY 2010.	Ongoing	http://www.netl.doe.gov/technologies/coalpower/fuelcells/seca
	Federal	Gasification Technologies Program	Research and development scheme for gasification technologies that convert carbon-based materials such as coal into synthesis gas that can be used for electricity generation or transport fuels. The scheme aims to reduce equipment costs, improve environmental outcomes and increase process reliability. This program received US$59 million in funding in FY 2010.	Ongoing	http://www.netl.doe.gov/technologies/coalpower/gasification/index.html

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	Federal	Carbon Capture Demonstration Program	Demonstration scheme for technologies for the large-scale capture of carbon dioxide from industrial processes, including support for projects that transport CO2 or inject it underground.	Ongoing	
	Federal	Renewable and Distributed Systems Integration	Development and demonstration activities that focus on integrating renewable energy, distributed generation and energy storage technologies into electricity transmission and distribution systems.	Ongoing	http://www.oe.energy.gov/renewable.htm
	Federal	Energy Frontier Research Centers	A set of research centres that involve collaboration between national laboratories, universities, non-profit organisations and for-profit firms that conduct basic research into 'energy needs' and the discovery and development of new materials. Projects are funded with around US$2 million to US$5 million per year for a five year period.	Ongoing	http://www.er.doe.gov/bes/EFRC/index.html
R&D - deployment and diffusion	Federal	Industrial Technologies Program (ITP)	Public-private partnerships, including cost-shared research and development, to improve energy efficiency in industry, with an aim of a 25 per cent reduction in industrial energy intensity over 10 years. The four main components are: Energy Intensive Industries (which covers aluminium, chemicals, forest products, glass, metal casting, mining, petroleum refining and steel), Emerging Technologies (technological and financial assistance for energy-intensive industries), Crosscutting Technologies (research and development for technologies used by multiple industries, including combustion, distributed energy and some forms of manufacturing), and ITP Commercial Successes (information program and tracking of energy savings). Other components include programs to reduce energy use in data centres, collaboration with the US Council for Energy-Efficient Manufacturing to develop and implement energy assessment standards, and the Industries of the Future program that involves cost-shared research and development projects to reduce the energy intensity of industry. Total funding was US$96 million in FY 2010.	Ongoing	http://www1.eere.energy.gov/industry/technologies/
	Federal	Vehicle Technologies Program (VTP)	Funding for public-private partnerships to increase energy efficiency through support for research and development activities, the demonstration or testing of technologies, technology transfer, and education. The scheme covers several technologies, including hybrid vehicles, energy storage, power electronics, advanced combustion engines, fuels, lubricants and materials. A major objective is to develop vehicles with reduced greenhouse gas emissions. In addition, the scheme includes the FreedomCAR and Fuel Partnership and 21st Century Truck Partnership, which identify research and development opportunities and facilitate agreements and grants. It also includes the Clean Cities program (which promotes 'alternative fuels', electric vehicles and hybrid vehicles), the Hydrogen Education Program (to increase awareness of hydrogen and fuel cell technologies), the Advanced Vehicle Testing Activity (which benchmarks vehicle performance), the Graduate Automotive Technology Education Centers of Excellence (educational scheme), and the Automotive X Prize (a competition for high-efficiency vehicles). Total funding was US$311.4 million in FY 2010.	Ongoing	http://www1.eere.energy.gov/vehiclesandfuels/
	Federal	Building Technologies Program	Partnership with state and local governments, industry and manufacturers to improve the energy efficiency of new and existing buildings and the equipment, components, and systems within them. Deployment activities include providing tools, guidelines, standards, training, and access to technical and financial resources. The program seeks to develop new technologies and solutions and then work with partners to implement the best available technologies. Funding was US$222 million in FY 2010.	Ongoing	
	Federal	FutureGen 2.0	Scheme to equip new coal-fired power plants with carbon capture and storage technology, including the FutureGen Alliance (a public-private partnership) that intends to design, construct and operate a commercial coal-fueled power plant with near zero emissions.	Ongoing	http://www.futuregenalliance.org http://www.fossil.energy.gov/news/techlines/2010/10033-Secretary_Chu_Announces_FutureGen_.html
	Federal	Clean Coal Power Initiative (CCPI)	Funding (US$2 billion over ten years) for coal-based electricity generation technologies that meet 'clean air' requirements, including coal-based gasification technologies. This includes commercial-scale demonstrations of 'clean coal' technologies in actual operating environments.	Ongoing	http://nepinstitute.org/get/CRS_Reports/CRS_Energy/Electric_Power_Generation/Clean_Coal.pdf http://www.netl.doe.gov/technologies/coalpower/cctc/ccpi/index.html
	Federal	Technology Commercialization Fund	Fund to promote early-state product development for renewable energy technologies. It supports the demonstration and deployment of technologies that were created at US national laboratories but have not been sufficiently developed to attract private capital.	Ongoing	http://www1.eere.energy.gov/commercialization/technology_commercialization_fund.html
	Federal	Integrated Biorefineries Program	Funding for biorefinery projects to develop commercial-scale integrated biorefineries that use a range of cellulosic feedstocks. Funding has been provided to 14 pilot-scale, four demonstration-scale and six other biorefinery projects. Total project investments are around US$1.3 billion.	Ongoing	http://www1.eere.energy.gov/biomass/integrated_biorefineries.html
	Federal	Smart Grid Technology Research, Development and Demonstration	Scheme to develop measurement strategies for the assessment of energy savings and other aspects of implementing smart meters. This includes demonstration projects for grid sensing technologies, communications, analysis and power flow control.	Ongoing	http://www.nist.gov/smartgrid
	Federal	Continuous Lower Energy, Emissions and Noise Program	Scheme that aims to develop and deploy existing technologies that reduce noise and emissions from aircraft, and that improve the efficiency of fuel combustion. The focus is on achieving faster integration of technologies that reduce energy use and support 'alternative' fuels in existing and new aircraft. There is cost-sharing of project costs with manufacturers of aircraft and aircraft components.	Ongoing	http://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=11538
Other					
Information provision or benchmarking	Federal	ENERGY STAR for Industry	Voluntary partnership program between the Environmental Protection Agency and industrial manufacturers. The Environmental Protection Agency provides industry-specific energy management tools, guidance, and resources, including the recognition of energy-efficient plants with an "ENERGY STAR for Plants" label. The Environmental Protection Agency offers benchmarking and assessment tools (such as the Energy Performance Indicator to benchmark the performance of plants in an industry), information, awards, labelling and recognition. Funding was US$2.5 million in FY 2010.	Ongoing	http://www.energystar.gov/index.cfm?c=industry.bus_industry

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	Federal	Net-Zero Energy Commercial Building Initiative	Primarily an information scheme, although with some government provision of services, that aims to achieve 'marketable net-zero-energy commercial buildings by 2025' through industry partnerships, research, tool development, the provision of energy simulation software, and three alliances (Retailer Energy Alliances, the Commercial Real Estate Energy Alliance, and the Hospital Energy Alliance). The scheme received $39 million of funding in FY 2010.	Ongoing	http://www1.eere.energy.gov/buildings/commercial_initiative/index.html http://www1.eere.energy.gov/buildings/alliances/
	Federal	Industrial Technologies Program Technical Assistance	The provision of resources to facilitate the implementation of 'energy management practices' in industrial plants, including energy assessments and audits through the Energy Services Development program, and Save Energy Now Leaders Partnerships that implement energy-saving emissions-reduction technologies. The aim of the scheme is to reduce industrial energy intensity by at least 25 per cent over 10 years.	Ongoing	http://www1.eere.energy.gov/industry/bestpractices/
	Federal	Energy SmartPARKS	Partnerships with the private sector to increase energy efficiency and renewable energy practices in national parks, including retrofitting of lighting systems, the purchase of electric vehicles, the installation of solar panels, energy audits, and the replacement of windows and furnaces.	Ongoing	http://www.energysmartpark.org http://www.nps.gov/applications/release/Detail.cfm?ID=829
	Federal	Builders Challenge	A voluntary scheme that provides technical information, resources and marketing tools to participating builders, with the aim of 220 000 high-performance, energy efficient houses to be built by 2012, and 1.3 million by 2013.	Ongoing	http://www1.eere.energy.gov/buildings/challenge/
	Federal	Clean Energy Initative	Two partnership programs that promote technologies that improve energy efficiency and reduce emissions. These are the Green Power Partnership (which provides information, technical support and resources to encourage the purchase of renewable energy for firms that meet a minimum requirement for the purchase of renewable baseload electricity), and the Combined Heat and Power Partnership (which promotes the use of heat and power cogeneration by providing technical guidance and project assistance).	Ongoing	http://www.epa.gov/greenpower/index.htm http://www.epa.gov/chp/index.html
	Federal	AgSTAR	Voluntary scheme that reduces emissions of methane from livestock waste management operations by promoting the use of methane recovery (biogas) technologies at confined animal feeding operations that manage manure as liquids or slurries. AgSTAR provides information, tools, and performance audits, designed to assist producers in the evaluation and implementation of these systems.	Ongoing	http://epa.gov/agstar/about-us/index.html
	Federal	Landfill Methane Outreach Program	Technical assistance and information provision for the recovery and use of landfill gas for energy. The scheme focuses on smaller landfills that are not required to collect and combust their landfill gas, as well as larger, regulated operations that are combusting landfill gas but not utilising it as an energy source. Support consists of feasibility analyses, project evaluation software, and sectoral and economic analyses.	Ongoing	http://epa.gov/lmop
	Federal	WasteWise	Scheme that encourages the reduction of municipal solid waste and some industrial wastes by encouraging waste prevention and recycling, and the purchase of recycled content products. Any organisation that can measure and report wastes is eligible to be a partner in the scheme. These partners agree to reduce or recycle wastes and are provided with promotional, educational and technical information, including access to an internet-based data management tracking tool (WasteWise Re-TRAC).	Ongoing	http://epa.gov/waste/partnerships/wastewise
	Federal	Clean Cities	A network of over 80 volunteer coalitions to develop public-private partnerships to promote alternative fuel use, advanced vehicle use, fuel blends, fuel efficiency, hybrid vehicles and idle reduction. The scheme provides information about funding options, technical assistance projects, and technical information. This includes the Campaign for an American Fuel (which provides information and tools to vehicle and fuel retailers to increase sales of biofuels) and the Clean Cities International Initiative (which facilitates the exchange of information and assists other countries to develop public-private sector partnerships to facilitate the uptake of 'alternative' fuels and 'alternative' fuel vehicles).	Ongoing	http://www1.eere.energy.gov/cleancities
	Federal	National Data Center Energy Efficiency Information Program	Data centre that coordinates activities from the Industrial Technologies Program Save Energy Now scheme, the Federal Energy Management Program and ENERGY STAR. This involves producing specifications, measurements and benchmarks, along with identifying 'best practices' to improve the way that energy efficiency and cost decisions are made. The scheme involves industry stakeholders that are developing and deploying tools and information resources to reduce energy consumption.	Ongoing	http://www.energystar.gov/index.cfm?c=prod_development.server_efficiency
	Federal	Fuel Economy Guide	A website (fueleconomy.gov) that provides consumers with information on the fuel efficiency and air pollution of passenger cars and trucks, from model years 1984 to present. The website also provides tools to enable comparisons between vehicles. The Fuel Economy Guide is produced annually and provides listings of vehicles that have the highest fuel efficiency, including hybrid vehicles and 'flexible-fuel' vehicles.	Ongoing	http://fueleconomy.gov
	Federal	Green Vehicle Guide	Annually-updated guide that provides consumers with information about fuel efficiency and emissions (including greenhouse gases) for cars and light trucks. Vehicles are given an environmental score from 0 to 10 to enable comparisons across vehicle classes.	Ongoing	http://epa.gov/greenvehicles
	Federal	ENERGY STAR for the Residential Market	Scheme that promotes the building of energy-efficient houses. This includes the provision of internet-based tools, a Quality Installation Program (for heating, ventilation, and air conditioning systems), and recommendations and cost-benefit analyses for housing finance agencies to improve the energy efficiency of housing for low-income households. There is also funding for improving the energy efficiency of new and existing houses. The scheme includes the Home Performance with ENERGY STAR scheme that provides online information and tools for assessing the energy efficiency of houses and other information on common problems and solutions, energy efficiency, and energy costs.	Ongoing	http://www.energystar.gov/index.cfm?c=home_improvement.hm_improvement_index
	Federal	ENERGY STAR for the Commercial Market	Provision of tools and recommendations for the measurement and management of energy use in the commercial building sector. In addition, various types of buildings can be awarded an ENERGY STAR label through the ENERGY STAR Labeled Buildings and Plants program.	Ongoing	http://www.energystar.gov/index.cfm?c=business.bus_bldgs
	Federal	Energy Savers	Scheme to educate consumers, homeowners and businesses on how to reduce energy use in buildings, vehicles and industrial plants. It identifies strategies to reduce energy use and provides a website that links to resources available from federal government agencies.	Ongoing	http://www.energysavers.gov
	Federal	Save ENERGY Save MONEY	Scheme that provides information to farmers and ranchers about conservation practices (including energy conservation) that reduce input costs and protect soil and water resources while maintaining production levels.	Ongoing	http://www.nrcs.usda.gov/technical/energy

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	Federal	Manufacturing Extension Partnership	Provision of technical expertise and services to small and medium sized manufacturers to reduce the consumption of energy and materials. This consists of non-profit centres that provide technical support and services to small and medium-sized manufacturers.	Ongoing	http://www.nist.gov/mep
	Federal	Federal Highway Administration Highways and Climate Change Activities	Various activities by the Federal Highway Administration to collect and disseminate information on climate change research, provide technical assistance to various parties, develop educational materials and coordinate activities with other government agencies.	Ongoing	http://www.fhwa.dot.gov/hep/climate/activities.htm
	Federal	Consortium for Research on Renewable Industrial Materials	Scheme that maintains a database of the environmental and economic impacts of various 'renewable materials' from forestry and wood manufacturing industries. This also involves research and educational activities.	Ongoing	http://www.corrim.org http://www.corrim.org/pubs/reports/annual/CORRIM_Annual_2010.pdf
	Federal	Green Power Network	Provision of news and information about 'green power' (renewable electricity) markets, and the tracking of industry progress to verify market outcomes.	Ongoing	http://apps3.eere.energy.gov/greenpower
	Federal	Electric Permitting, Siting and Analysis	A scheme to undertake analyses of physical, regulatory and institutional barriers that impede the efficient and secure operation of electricity transmission and distribution systems. This includes collaboration with regional, state and local organisations and utilities. Funding was US$6.4 million in FY 2010.	Ongoing	http://www.oe.energy.gov/our_organization/psa.htm
	Federal	Building Energy Software Tools Directory	Database of information on software tools for evaluating energy efficiency and renewable energy use in buildings.	Ongoing	http://apps1.eere.energy.gov/buildings/tools_directory
	Federal	Whole Building Design Guide	A website that provides information to government and industry practitioners on building-related technologies from a 'whole buildings' perspective. This includes technologies that reduce energy consumption and greenhouse gas emissions. The guide is produced through collaboration between federal government agencies, private sector companies, non-profit organisations and educational institutions.	Ongoing	http://www.wbdg.org
	Federal	Transportation and Climate Change Clearinghouse	A website that provides information on greenhouse gas inventories, methods and tools for analysing emissions, emissions-reduction strategies, and impacts of climate change on transport infrastructure.	Ongoing	http://climate.dot.gov
	Federal	Renewable Resource Data Center	Provision of information on renewable energy resources through tools, maps, reports and data collections.	Ongoing	http://www.nrel.gov/rredc
	Federal	Clean Energy Application Centers	Support for the technology transfer of combined heat and power, 'district energy', waste heat recovery and other 'clean energy' systems. This includes market assessments, education and outreach activities, and technical assistance such as site assessments, feasibility studies and financial analyses.	Ongoing	http://www1.eere.energy.gov/industry/distributedenergy/racs.html
	Illinois	Large-Customer Energy Analysis Program	Support and training provided to large energy users (with energy costs greater than US$500 000 per year) to identify and implement energy efficiency technologies, develop energy audits and plans, and share information.	Ongoing	http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=IL19F&re=0&ee=1
Labelling scheme	Federal	Fuel Economy Labelling	Mandatory fuel efficiency labels for cars and trucks, including miles per gallon estimates for city and highway vehicle use.	Ongoing	http://www.epa.gov/fueleconomy/basicinformation.htm http://www.epa.gov/fueleconomy/label.htm
	Federal	Appliance Labelling Rule	Certain appliances must be labelled with estimates of the product's energy consumption or energy efficiency. This includes air conditioners, clothes washers, dishwashers, water heaters, refrigerators, freezers, furnaces, boilers and ceiling fans. Mandatory labelled may also be extended to cover televisions, personal computers and video equipment.	Ongoing	http://www.ftc.gov/bcp/conline/edcams/eande/index_applrule.html
	Federal	ENERGY STAR Labeled Products	A voluntary labelling scheme that identifies energy-efficient products. ENERGY STAR Products must meet certain minimum energy standards to be eligible for the ENERGY STAR label. There are more than 60 product categories, incldluing home appliances, heating and cooling appliances, water heaters, insulation, home electronics, office equipment, lighting, and commercial food service appliances. The scheme also includes the provision of information and tools to businesses and households.	Ongoing	http://www.energystar.gov/index.cfm?fuseaction=find_a_product http://www.epa.gov/cpd/pdf/2008AnnualReportFinal.pdf
	Federal	BioPreferred Program	A labelling scheme that identifies biobased products (commercial or industrial products that are composed mostly of biological products). The scheme also includes a requirement that federal government agencies and their contractors give 'preference' to purchasing biobased products.	Ongoing	http://www.biopreferred.gov
Advertising or educational scheme	Federal	EnergySmart Schools	Provision of information and resources to schools about energy efficiency, including financial information, 'best practices' advice for systems and equipment (including 'alternative fuel' vehicles), and resources for teachers to develop energy-related curricula.	Ongoing	http://www1.eere.energy.gov/buildings/energysmartschools/
	Federal	Solar Decathlon	Competition for university students to design, build and operate energy-efficient solar houses, through a set of 10 contests. The aims include to support solar energy technology and to demonstrate the potential of 'zero energy' houses.	Ongoing	http://www.solardecathlon.gov
	Federal	Green Racing Initative	Motor sport competition that aims to support the development of more fuel efficient vehicle propulsion systems for eventual use in consumer vehicles.	Ongoing	http://www.epa.gov/otaq/ld-hwy/420f10058.htm
	Federal	National Biodiesel Education Program	Scheme to raise awareness (and utilisation) of biodiesel, including the provision of educational and technical support, information gathering and dissemination, coordination of educational programs with the National Biodiesel Board, identifying benefits of biodiesel, and identifying information gaps. The scheme focuses on market barriers to the commercialisation of biodiesel and develops strategies to eliminate these.	Ongoing	http://www.biodiesel.org/usda/pdfs/USDA_Ed_Factsheet2010.pdf
	Federal	EPA Climate Change Public Outreach Tools	Educational tools including online household 'emissions calculators', which allow consumers to identify the fuel mix and emissions for the energy supplied to their local area in order to estimate household greenhouse gas emissions. Other tools include the Home Energy Saver tool, the Power Profiler Tool, and the Greenhouse Gas Equivalencies Calculator.	Ongoing	http://www.epa.gov/climatechange/emissions/individual.html

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	Federal	EcoCAR Challenge	Vehicle technology competition that encourages engineering students to design and build 'advanced' vehicles that minimise the environmental impact of personal transportation. Teams of engineers that qualify for the competition receive US$10 000 initially, and the competition lasts three years. Participating universities also provide support to students. EcoCAR 2 will commence in 2011. The scheme is jointly administered with General Motors and received US$2 million in funding in FY 2010.	Ongoing	http://www.ecocarchallenge.org/ecocar2/index.html
Broad target or intergovernmental framework	Federal	2011 'State of the Union' targets	A set of federal government targets, including: - the elimination of fossil fuel subsidies over time - a 'clean energy standard', with a target of 80 per cent of US electricity production to come from 'clean energy' sources by 2035 (including renewable energy, natural gas, nuclear energy and 'clean coal'). This is expected to be implemented through regulations on electricity utilities - government investment in 'clean energy' research and development - government investment in high-speed rail infrastructure - an increase in the number of electric cars in the United States to 1 million by 2015 (reiteration of an existing target).	Committed	
	Federal	American Recovery and Reinvestment Act of 2009	The American Recovery and Reinvestment Act of 2009 (US) provided substantial funding to several emissions reduction and energy schemes. This included $16.8 billion for the Office of Energy Efficiency (within the Department of Energy) to fund energy efficiency projects; renewable energy projects; tax credits, grants and rebates; and national laboratories. Most of the funding was one-off. There was also around $80 billion for 'clean energy' research, development and deployment. Over $50 billion of this was in the form of direct appropriations, and $30 billion was in the form of tax credits. The funding supported new and existing programs.	Many measures were one-off, although increased funding was provided to some existing schemes.	http://www1.eere.energy.gov/recovery http://www.recovery.gov
	Federal	Executive Order 13514: Federal Leadership in Environmental, Energy, and Economic Performance	A federal government executive order that requires federal government agencies and departments to monitor and record greenhouse gas emissions, set greenhouse gas reduction targets for FY 2020, increase energy efficiency, reduce petrol consumption, conserve water and reduce waste. Targets under the order include a 30 per cent reduction in vehicle fleet petrol use by FY 2020 (relative to FY 2005) via a set of interim 2 per cent annual reduction targets (implemented through the Federal Fleet Management Guidance), and net-zero-energy buildings by 2030. Support to agencies to meet these targets is partly provided through the Federal Electronics Challenge scheme, which provides agencies with resources and technical assistance to purchase more efficient electronic products, as well as to reduce the environmental impact of purchasing, using and disposing of electronic products.	Ongoing	http://www1.eere.energy.gov/femp/regulations/eo13514.html http://www1.eere.energy.gov/femp/pdfs/fleetguidance_13514.pdf
	Federal	Executive Order 13423: Strengthening Federal Environmental, Energy, and Transportation Management	A federal government executive order that sets targets for federal government agencies and departments to reduce their energy intensity by 3 per cent annually until the end of FY 2015, or by a total of 30 per cent below a 2003 baseline by FY 2015. There are also requirements for agencies to reduce greenhouse gas emissions, improve energy efficiency, procure energy from renewable sources, adopt sustainable environmental practices and reduce the total consumption of petroleum products by their vehicle fleet. In particular, agencies are required to reduce vehicle fleet petroleum consumption by 2% annually, and increase alternative fuel use by 10% annually, through to FY 2015 (from a FY 2005 baseline) (implemented through the Federal Fleet Management Guidance).	Ongoing	http://www1.eere.energy.gov/femp/pdfs/fleetguidance_13514.pdf
	Federal	Executive Order 13221: Energy Efficient Standby Power Devices	A federal government executive order that requires federal government agencies and departments, when purchasing commercially available products, to purchase products that use at most one watt of power in standby mode. When such products are not available, agencies are directed to purchase products with the lowest standby power wattage while in power-saving mode. The executive order states that these actions should only be taken where doing so would be cost-effective and practicable.	Ongoing	http://www1.eere.energy.gov/femp/pdfs/eo13221.pdf
	Federal	One Million Advanced Technology Vehicles	A goal to have one million 'advanced technology vehicles' in the US by 2015, to be achieved through tax credits, investment in research and development, and the development of electric vehicle infrastructure.	Ongoing	http://www.whitehouse.gov/sites/default/files/other/fact-sheet-one-million-advanced-technology-vehicles.pdf
	Federal	Building Energy Codes Program	A program to make building energy codes more stringent to improve energy efficiency. The policy involves proposing and advocating improvements to national model energy codes; the development of improved federal energy codes for mobile homes; and financial and technical assistance to states for adopting, implementing or enforcing building energy codes.	Ongoing	http://www.energycodes.gov/status/
	Federal	Federal Energy Management Program	Scheme that aims to reduce the cost and environmental impact of federal government activities by improving energy efficiency and water conservation, promoting the use of distributed and renewable energy, and improving utility management decisions at federal government sites. Technical and financial assistance are provided, including project transaction services, applied technology services and decision support services. The scheme also provides guidance and assistance on implementing and managing energy efficient and 'alternative fuel' vehicles within federal government fleets. In addition, the scheme includes the Interagency Sustainability Working Group which coordinates building sustainability efforts by federal government agencies.	Ongoing	http://www1.eere.energy.gov/femp
	Federal	Geothermal Resource Leasing and Geothermal Resources Unit Agreements	Requirements for competitive leasing arrangements for geothermal energy development on federal government lands, as well as simplified royalty calculations and the sharing of royalties with local governments where production occurs.	Ongoing	
	Federal	Federal Utility Partnership Working Group	A partnership between federal government agencies, utilities and energy service companies that facilitates communication and develops strategies for cost-effective energy efficiency and water conservation projects at federal government sites.	Ongoing	http://www1.eere.energy.gov/femp/financing/uescs_fupwg.html
	Federal	Aviation Fuel Efficiency Goal	A goal set by the Department of Transportation to improve aviation fuel efficiency per revenue plane-mile by one per cent annually through to FY 2011, compared to the three year average for 2000-2002. This is to be achieved through technologies and procedures that improve air traffic management, and through engine and aircraft designs that improve fuel efficiency.	Ongoing	

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	Federal, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming.	Western Renewable Energy Zones (WREZ) Project	Scheme run by the Department of Energy and state governments to generate reliable information to support the cost-effective development of renewable energy, and to form transmission plans for delivering energy to load centres. The policy concerns the Western Interconnection grid, which covers11 US States (plus Alberta and British Columbia in Canada, and Baja California in Mexico).	Ongoing	http://www.westgov.org/index.php?option=com_content&view=article&id=219:western-renewable-energy-zones&catid=102&Itemid=81
	Arizona, California, Montana, New Mexico, Oregon, Utah, Washington.	Western Climate Initiative	An agreement between seven US states and four Canadian provinces (British Columbia, Manitoba, Ontario and Québec) to reduce greenhouse gas emissions to 15 per cent below 2005 levels by 2020. The central component will be a cap-and-trade emissions trading scheme which is scheduled to be introduced in some jurisdictions in 2012. In addition, there are commitments to develop and implement other measures including energy efficiency schemes, support for renewable energy, vehicle and fuel emissions standards, transport planning, performance benchmarking for high emissions industries, and educational programs.	Ongoing	http://www.westernclimateinitiative.org
	State	State Emissions Targets and Caps	State targets to reduce emissions, with varying stringency, timing and enforceability. In some states these targets are broad commitments, whereas in other states specific policies are in place (or committed) to achieve these targets.	Ongoing	http://www.pewclimate.org/what_s_being_done/in_the_states/emissionstargets_map.cfm http://www.ncsl.org/?TabId=13240
	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont.	New England Governors and Eastern Canadian Premiers Climate Change Action Plan	Commitment made in 2001 by the governors of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont in the US, and the premiers of New Brunswick, Newfoundland and Labrador, Nova Scotia, Prince Edward Island, and Québec in Canada, to reduce greenhouse gas emissions to 1990 levels by 2010, 10 per cent below 1990 levels by 2020 and by 75-85 per cent in the long term, and mostly in the electricity and transport sectors. This action plan was a precursor to the RGGI.	Ongoing	http://www.newenglandclimate.org/index.htm
	California, Connecticut, Delaware, Hawaii, Illinois, Maine, Massachusetts, Michigan, Minnesota, Montana, New Jersey, New York, Oregon, Pennsylvania, Rhode Island, Vermont, Wisconsin, District of Columbia.	Public Benefit Funds	Funds for energy efficiency and renewable energy in 17 states and the District of Columbia. Funds are collected through a small charge on the bills of electricity customers, or through specified contributions from utilities. Funding is used for low-income household energy assistance, 'weatherization programs', investment in renewable technologies and subsidies for efficient appliances. The Clean Energy States Alliance has been formed by 18 states to coordinate schemes that are funded by public benefit funds.	Ongoing	http://www.pewclimate.org/what_s_being_done/in_the_states/public_benefit_funds.cfm http://www.worldenergy.org/documents/congresspapers/341.pdf
	State	Securing a Clean Energy Future Initiative	Initiative by the National Governor's Association to promote 'clean energy' policies that encourage energy efficiency and conservation, the use of non-petroleum fuels, reductions in greenhouse gas emissions, and research and development in 'clean energy' technologies.	Ongoing	http://www.nga.org/portal/site/nga/menuitem.9123e83a1f6786440ddcbeeb501010a0/?vgnextoid=6c3bd5cbaf4d6110VgnVCM1000001a01010aRCRD&vgnextchannel=4b18f074f0d9ff00VgnVCM1000001a01010aRCRD
	Intergovernmental	Energy Efficiency and Conservation Block Grants	A system of formula and competitive grants to US states, territories, local governments (cities and counties) and Native American nations to fund investments in energy efficiency and conservation projects that reduce fossil fuel emisisons; reduce total energy use; improve energy efficiency in transport, building and other sectors; and that 'create and retain jobs.' Around US$3.2 billion in funding was available in 2010 from the American Recovery and Reinvestment Act of 2009 (US).	Ongoing	http://www1.eere.energy.gov/wip/eecbg.html
	Intergovernmental	Qualified Energy Conservation Bonds	Qualified tax credit bonds that can be used by state, local and tribal governments to finance eligible energy projects. Funds are allocated to state governments (who then distribute them to local governments) based on their share of the US population. A total of $3.2 billion in bonds can be issued by state or local governments. Since March 2010, bond issuers can recoup part of the interest paid on a qualified bond through a direct subsidy from the US Treasury (Energy Efficiency and Conservation Block Grants). Borrowers generally only pay back the principal of the bond, with the bondholder receiving federal tax credits instead of bond interest, and bondholders receiving only 70 per cent of the full rate set by the US Treasury. Bonds can be used to fund energy efficiency projects in public buildings, renewable energy projects, research and development, mass commuting facilities that reduce energy use, some demonstration projects, and educational schemes for energy efficiency.	Ongoing	http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US51F&re=1&ee=0
	Intergovernmental	State Energy Program	Competitive and formula grants and technical assistance provided to states and territories to promote energy conservation and reduce the growth in energy demand. States use funds to develop plans that identify opportunities to adopt renewable energy and energy efficiency technologies. States match formula allocations with 20 per cent funding. Funding for the scheme was US$50 million in FY 2010.	Ongoing	http://www1.eere.energy.gov/wip/sep.html
	Intergovernmental	National Clean Diesel Campaign	Scheme that aims to reduce diesel emissions and facilitate the implementation of emissions-control technologies, involving state and local governments and non-profit organisations as partners. Activities include the development of emissions standards for locomotive and marine diesel engines, and reducing emissions from existing diesel engines by promoting 'cost-effective' strategies (such as the use of different fuels, retrofitting and repairing existing fleets, and idling reduction). Funding is available for projects that reduce diesel emissions and exposure.	Ongoing	http://www.epa.gov/cleandiesel/grantfund.htm
	Intergovernmental	Federal Transit Administration Grants	Funding for public bodies (states, cities, towns, regional government and transit authorities) for constructing and operating transit services. The scheme includes the Clean Fuels Grant Program (projects and costs relating to the use of clean fuel, biodiesel or electric buses).	Ongoing	http://www.fta.dot.gov/grants_financing.html
	Intergovernmental	Tribal Energy Program	Financial and technical assistance, as well as education and training, in tribal areas for the evaluation and development of renewable energy and energy efficiency. A competitive process is used to allocate funds to tribal governments.	Ongoing	http://apps1.eere.energy.gov/tribalenergy

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	Federal and intergovernmental	National Action Plan for Energy Efficiency	Engagement of the Department of Energy and Environmental Protection Agency with electricity and gas utilities, state utility regulators and energy agencies, energy consumers, and others. The Action Plan focuses on state-level policies that affect the level of investment in energy efficiency. It is currently developing a policy framework to implement 'cost-effective' energy efficiency measures by 2025. The scheme also involves the provision of best-practice guides, reports and tools.	Ongoing	http://www.epa.gov/cleanenergy/energy-programs/suca/resources.html
	Intergovernmental	Property-Assessed Clean Energy financing programs	Schemes (in plcae in 20 states) that allow state and local governments to 'attach' the cost of energy efficiency improvements in dwellings to a property, rather than an individual borrower (where permitted by state laws). Low-interest long-term loans are provided by local governments, under the authority of state governments, to fund 'energy improvements' by property owners. Property owners enter into a contract to repay the loan over time (up to 20 years) on their property tax bill. The improvements funded are usually solar PV, geothermal heat pumps, fuel cells, insulation and high-efficiency windows.	Ongoing	http://www.pewclimate.org/what_s_being_done/in_the_states/property_assessed_clean_energy http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CA198F&re=1&ee=0
	Intergovernmental	Clean Fuels Grant Program	Grants for state or municipal transit agencies to purchase low-emissions buses and related equipment, construct 'alternative fuel' stations, modify garage facilities to accommodate 'clean fuel' vehicles, and encourage the use of biodiesel. US$89.7 million was awarded to 36 recipients in 2010.	Ongoing	http://www.fta.dot.gov/funding/grants/grants_financing_3560.html http://www.fta.dot.gov/funding/apportionments/grants_financing_12353.html
	Intergovernmental	Congestion Mitigation and Air Quality Improvement Program	Funding to state transport departments, municipal planning organisations and transit agencies for projects to reduce transport-related emissions and improve air quality. This includes travel demand management strategies, funding for idle reduction equipment, the development of alternative fuel infrastructure, and the conversion of public fleets to use 'cleaner' fuels.	Ongoing	http://www.fhwa.dot.gov/environment/air_quality/cmaq
	Intergovernmental	State Climate and Energy Program	Voluntary scheme that assists states to review and adopt programs that develop clean energy. Tools and analyses are provided to support state government schemes that address air quality, support cost-effective energy efficiency projects, increase the use of renewable energy, and reduce greenhouse gas emissions. Best Practices Guides are also published.	Ongoing	http://www.epa.gov/statelocalclimate/state/index.html
	Intergovernmental	Local Climate and Energy Program	Assistance to local and tribal governments to implement cost-effective clean energy strategies and greenhouse gas reduction measures. Assistance is provided in the form of peer exchange and training opportunities for local and tribal governments; competitive grant funding; and the provision of planning, policy, technical and analytical information.	Ongoing	http://www.epa.gov/statelocalclimate/local/index.html
	Intergovernmental	Pollution Prevention Grants Program	Support for the establishment and expansion of state and tribal pollution prevention programs that cover sectors such as energy, transport, industry and agriculture. The scheme supports state programs to assist businesses and industries to identify better environmental strategies and solutions for complying with federal and state environmental regulations. The majority of grants provided under the scheme fund state-based projects for technical assistance, training, outreach, education, regulatory integration, data collection, research, demonstration projects, and recognition programs.	Ongoing	http://www.epa.gov/p2/pubs/grants/ppis/ppis.htm
	Intergovernmental	Climate Friendly Parks	Provision of management tools and resources to national parks to address climate change within national parks and surrounding areas. Resources are provided to measure and record park-based greenhouse gas emissions, develop sustainable strategies to mitigate these emissions and adapt to climate change impacts, and for educational activities.	Ongoing	http://www.nps.gov/climatefriendlyparks
	Intergovernmental	Native American Housing Block Grants	Grants to fund new construction (including 'affordable housing'), the acquisition and rehabilitation of land, and infrastructure development on Native American Reservations in ways that support energy efficiency and conservation. Eligible recipients must submit an Indian Housing Plan and an Annual Performance Report each year.	Ongoing; funding is available until September 2011.	http://www.hud.gov/offices/pih/ih/grants/ihbg.cfm
	Intergovernmental	Technical Assistance Program	Provision of short-term access to experts at the Department of Energy national laboratories to state and local government officials, to provide assistance with renewable energy and energy efficiency policies that are not covered by existing Department of Energy programs.	Ongoing	http://www1.eere.energy.gov/wip/assistance.html
	Intergovernmental	Healthy High-Performance Schools	Grants to encourage state and local governments and school systems to build 'green schools'. This includes the provision of technical assistance for developing school building plans and financial assistance for building. US$1.5 million in funding has been authorised for the 2010 to 2013 fiscal years.	Ongoing	http://cfpub.epa.gov/schools/top_sub.cfm?t_id=301&s_id=63
	Intergovernmental	Energy Sustainability and Efficiency Grants and Loans for Institutions	Provision of information, technical assistance, grants and loans to support energy efficiency projects at public institutions. US$250 million for grants and US$500 million for loans has been authorised for the 2009 to 2013 fiscal years.	Ongoing	
	Intergovernmental	Transit Investment in Greenhouse Gas and Energy Reduction Program	Grant funding to state and local governments for capital investments that reduce the energy consumption or greenhouse gas emissions of public transportation systems. US$75 million was awarded to 27 recipients in 2010.	Ongoing	http://www.fta.dot.gov/assistance/research_11424.html
	California	Green Building Action Plan	A goal to increase the energy efficiency of state government buildings and reduce the use of grid-based energy in these buildings by 20 per cent of 2003 levels by 2015 (under California Executive Order S-20-04).	Ongoing	http://www.energy.ca.gov/greenbuilding/index.html
	Intergovernmental (Illinois)	Public Sector New Construction and Retrofit Program	Grants to public sector entities for the design of new or retrofitted buildings to increase energy efficiency. Grants are provided from US$0.20 to US$1.00 per square foot, depending on the amount by which the project exceeds Illinois' commercial energy code.	Ongoing	http://smartenergy.arch.uiuc.edu/html/NewConstructionProgram.html
	Intergovernmental (Texas)	LoanSTAR	Low-interest loans provided to public entities, including state government agencies, schools, universities and non-profit hospitals, for energy cost-reduction measures (including heating and air conditioning systems, lighting and insulation). Funds can be used for retrofitting existing equipment or financing the additional costs of new equipment (that is, the incremental cost above conventional equipment).	Ongoing	http://seco.cpa.state.tx.us/funding/nolfa

Policy type	*Jurisdiction*	*Name*	*Description*	*Status and duration*	*References*
	Intergovernmental (Texas)	Renewable Energy Demonstration Pilot Program	Grants to local governments for the installation of renewable energy projects, with priority given to those that use wind or solar energy for water and wastewater treatment. Biomass, tidal, wave and hydroelectricity projects are also eligible. Individual grants are limited to US$500 000. Only non-entitlement local governments are eligible and they must demonstrate that at least 51 per cent of residents that benefit meet low-to-moderate income criteria.	Ongoing	http://www.tdra.state.tx.us/TxDRA/programs/renewenergy.aspx
Voluntary agreement	Federal	Coalbed Methane Outreach Program	Voluntary scheme to reduce methane emissions from coal mining by providing support to mining companies to assist with the capture and use of methane from mining operations.	Ongoing	http://epa.gov/cmop/index.html
	Federal	Natural Gas STAR Program	Voluntary partnership between the Environmental Protection Agency and oil and natural gas firms (including producers and distributors) that aims to identify and promote the implementation of technologies and practices that improve operational efficiency and reduce methane emissions. This targets emissions both domestically and internationally.	Ongoing	http://epa.gov/gasstar/index.html
	Federal	SF6 Emission Reduction Partnership for Electric Power Systems	Collaboration between the Environmental Protection Agency and the electric power industry to identify and implement cost-effective solutions to reduce sulfur hexafluoride (SF6) emissions, including improvements in the leak rate of new equipment, refurbishing of older equipment, and the use of more efficient operation and maintenance techniques.	Ongoing	http://epa.gov/highgwp
	Federal	SF6 Emission Reduction Partnership for the Magnesium Industry	Partnerships between the Environmental Protection Agency and magnesium producers to reduce emissions of sulfur hexafluoride from magnesium production and casting processes. The Environmental Protection Agency assists partners in the review of greenhouse gas emissions-reduction strategies and technologies, and serves as a clearinghouse for technical information on strategies to reduce SF6 emissions.	Ongoing	http://epa.gov/highgwp
	Federal	Voluntary Aluminum Industrial Partnership	Partnerships between the Environmental Protection Agency and aluminium producers to reduce perfluorocarbon, tetrafluoromethane, and hexafluoroethane emissions.	Ongoing	http://epa.gov/highgwp
	Federal	PFC Reduction/Climate Partnership for the Semiconductor Industry	Partnerships between the Environmental Protection Agency and the semiconductor industry to support voluntary efforts to reduce emisisons of perfluorocarbons, trifluoromethane, nitrogen trifluoride and sulfur hexafluoride. The partnerships have involved the identification and implementation of process improvements, alternative chemical use, emissions capture and reuse, and emissions destruction technologies.	Ongoing	http://epa.gov/highgwp
	Federal	HFC-23 Emission Reduction Partnership	Scheme that encourages companies to develop and implement technically feasible 'cost-effective' processing practices or technologies to reduce HFC-23 emissions from the manufacture of HCFC-22.	Ongoing	http://epa.gov/highgwp
	Federal	Mobile Air Conditioning Climate Protection Partnership	Partnerships with industry to demonstrate technologies that reduce greenhouse gas emissions from vehicle air conditioning. There are partnerships between the US Environmental Protection Agency, Society of Automotive Engineers International and Mobile Air Conditioning Society Worldwide. Membership also includes government and non-government organisations in Australia, Canada, Europe and Japan. These partnerships develop new air conditioning technologies, including 'next-generation' mobile air conditioning systems, that reduce refrigerant emissions (especially of CFC-12 and HFC-134a) and develop alternative refrigerants to HFC-134a.	Ongoing	http://www.epa.gov/cppd/mac
	Federal	GreenChill Advanced Refrigeration Partnership	Partnerships with the supermarket industry and other entities to promote technologies, strategies and practices that reduce the emissions of refrigerants, including greenhouse gases and ozone-depleting substances.	Ongoing	http://www.epa.gov/greenchill
	Federal	Responsible Appliance Disposal Program	Partnerships with industry to recover ozone-depleting chemicals from old refrigerators, freezers, air conditioners and dehumidifiers. The scheme requires that commercial partners dispose of refrigerant-containing appliances using the best available environmental practices.	Ongoing	http://www.epa.gov/ozone/partnerships/rad
	Federal	Green Power Partnership	Voluntary scheme whereby advice, technical support, tools and resources are provided to participating organisations to encourage the use of 'green power' (produced from eligible renewable energy sources, including solar, wind, geothermal, biomass and some hydro). Organisations sign an agreement to purchase green power that meets or exceeds certain benchmarks.	Ongoing	http://epa.gov/greenpower