Department of Environment and Heritage

Waste and Recycling in Australia

Short Paper

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Hyder Consulting

Department of Environment and Heritage

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1 Introduction and background

In 2003 the Environment Protection and Heritage Council agreed that Australian waste policies are 'too narrow, reactive and focused on end-of-pipe waste, rather than sustainable, proactive, life-cycle oriented materials management'.

In response to this, a Productivity Commission Inquiry was proposed in May 2004 as one way to achieve a better understanding of waste issues at the national level and to inform future policy development. The Productivity Commission's Inquiry into waste generation and resource efficiency in Australia commenced in late October 2005.

To inform its submission to the Inquiry, the Department of the Environment and Heritage has commissioned Hyder Consulting (now incorporating Nolan-ITU) to provide a short paper on waste and recycling in Australia, including data on waste disposal in Australia, a summary of the environmental impacts of waste disposal, and an identification and discussion of the barriers to recycling consumer waste products.

Data on waste disposal has been developed and reported in some states over recent years. Similarly, data on recycling activity has been expanding on a state basis.

This report is the first time that this key data has been brought together for all the state and territories where data is available. It enables an assessment of waste generation, diversion and disposal across all sectors (municipal, commercial and industrial, and construction and demolition) for each state. It also highlights the differences in scope and methodology relating to the state based data. It enables analysis of recycling across each material in each sector and each state and allows key stakeholders to draw on a set of data for a single time period.

2 Waste and recycling data

2.1 Introduction

This section summarises information collated on waste disposal to landfill and recycling data in Australia. It includes figures on:

- the quantity generated each year on a State/Territory and national basis
- the composition of the waste stream
- historical and projected trends.

There are major differences throughout Australia with regard to both actual disposal and recycling performance. In addition, a number of methods for data collection and classification were encountered. Therefore, one of the aims of this report is to collate data using consistent definitions and assumptions, where possible, to enable comparison. Inconsistencies between data collection methodologies have also been identified.

No new data has been generated and no estimates were made for the purpose of this report. Data gaps have been identified and are highlighted.

2.1.1 Data types

The two possible fates of waste materials are either disposal, generally to landfill, or recovery. Policy objectives for each management option vary and require different performance indicators and data. Informed decision making requires that performance is measured in accordance with the policy objectives of waste management based on best available data and methods.

2.1.2 Traditional data requirements

Reduction of waste to landfill has traditionally been a guiding policy objective of waste management throughout all jurisdictions in Australia. Measured as the quantity of waste disposed to landfill per capita or per unit of gross domestic product (GDP) for aggregated waste streams, it serves as an indicator of environmental pressure caused by human activity (wastefulness) as well as an indicator of landfill related impacts. Recycling, measured as the quantity of material diverted per capita or per unit of GDP, indicates the response of society to manage environmental concerns as well as avoided impacts such as global warming and landfill space.

2.1.3 Data needs for resource efficiency and sustainability

More recent policy objectives that target waste avoidance and seek to decouple environmental impact and economic growth, and facilitate resource efficiency, require different data sets and assessment tools. In order to understand the role of waste management data in policy decision making, it is important to consider the different goals of waste management and the associated data sets and their application. These are summarised in Table 2-1.

Table 2-1 Different goals of waste management, associated data sets and their application

Policy Objective	Integrated Waste Management	Data Type	Data Quality / Source	Data Application for Policy
Sound waste disposal	Reduce waste to landfill	**Waste to landfill** ***Mass of waste by stream:*** *Municipal solid waste (i.e. Council & domestic)* *Commercial & industrial* *Construction & demolition*	Data sourced from quarterly returns of depot operators. Collated by state authorities. Reliable data on landfill disposal tonnages for municipal solid waste, but not for commercial & industrial and construction & demolition.	Used to indicate trends in materials intensity (wastefulness) of human activity. Measure of impact associated with landfill space depletion.
Resource Efficiency Decouple growth and impact	Commodity recycling	**Material Recovered** ***Mass of Material*** *(e.g. steel, glass, etc)*	Data sourced by surveys, most accurate when rebate schemes operate.	Measure trends in the effectiveness of policy responses.
	Resource Efficiency & Waste Avoidance (disassembly, repair, extend life, renovation National Resource Accounting)	**Input output flow analysis** ***By product sales*** *Consumption & fate (e.g. computers, batteries, etc)*	Limited and poor waste data available by product. Consumption data from marketing databases may be purchased but emphasis is inappropriate.	Used to inform strategies for recovery of materials. Identify most effective point of interception for life extension, recovery, repair etc.
		National Resource Accounts ***By sector*** *Input/Output analysis by: virgin material (mineral ores and biotic assets)*	Increasingly available. Most OECD countries have developed national accounts.	Used to measure actual material throughput of different sectors for priority setting. Material flows per capita measured as 200 tonnes/person/year(1).
		Life Cycle Assessment *Product or service measured by resource inputs & pollutant outputs*	High availability, Rigorous International standard, data quality improving but still poor. Most OECD countries have invested in LCA and Waste Management data.	Used to assess goods and services in terms of: materials intensity, environmental impact, net externalities. Environmental value of kerbside recycling (avoided externalities) estimated at 68 dollars per person per year(2).
		Substance Flow Analysis *Region by substance*	Leadership by academic institutes on substance flows (lead, zinc etc).	Identify the substances of regional concern and trace to related industrial activities.

Policy Objective	Integrated Waste Management	Data Type	Data Quality / Source	Data Application for Policy
		Ecological Footprint *Hectares of land/capita*	Most OECD countries have measured and reported footprint impacts.	Easy to communicate measure of materiality as hectares of land. Neglects air and water pollution.
		Materials Intensity per Unit Service - *throughput*	Limited to selected academic institutes. No international standard.	Used to assess goods and services in terms of materials intensity. Neglects environmental significance of material load.

(1) Measuring Australia's Progress – Consumption, Australian Bureau of Statistics April 2002

(2) Nolan-ITU Independent Assessment of Kerbside Recycling in Australia, 2002

2.2 Disposal and recycling

This section presents a consolidation of available information on disposal and recycling performance across the main states of Australia. References and explanations of assumptions and calculations are also provided.

Unless otherwise noted, data presented in this report is for the 2002–03 financial year. Whilst more recent data is available for Victoria and the ACT, 2002–03 data has been used to ensure consistency when comparing data gathered from the other states.

As may be seen in the following sections, the available information (in terms of type and quality) from each State/Territory varies greatly.

2.2.1 National totals

Table 2-2 shows the level of total waste generation (disposal and recycling) and diversion rates across the main states of Australia during 2002–03.

Table 2-2 Waste generation and diversion rates for the main states of Australia 2002–03

State / Territory	Disposed	Recycled	Total Generated	Diversion Rate
	Tonnes			Percent
NSW	6,341,000	5,830,000	12,170,000	48%
Victoria	4,180,000	4,429,000	8,609,000	51%
Qld	2,722,000	1,251,000	3,973,000	31%
WA	2,696,000(1)	826,000	3,522,000	23%
SA	1,277,000	2,156,000(2)	3,433,000	63%
ACT	207,000	467,000(3)	674,000	69%
Total(4)	**17,423,000**	**14,959,000**	**32,382,000**	**46%**

(1) The total disposal figure for WA is for metropolitan Perth.
(2) The total recycling figure for SA includes meat waste, a prescribed industrial waste.
(3) The total recycling figure for the ACT includes cooking oil and fat, motor oil, salvage and reuse, and paint.
(4) There is currently no data available for Tasmania and the Northern Territory.

While there is no waste or recycling data available for Tasmania and the Northern Territory, limited data on household recycling volumes is published in the *'Reports from Jurisdictions on the Implementation of the Used Packaging Materials NEPM'* (NEPC 2003) and is included in Appendix 1 of this paper.

Table 2-3 shows the consolidated disposal, recycling, generation and diversion rates for each sector – municipal, commercial and industrial (C&I), and construction and demolition (C&D) – across Australia.

Material based summaries for disposal and recycling by State/Territory are presented in Appendix 1 and highlight the inconsistencies in reporting and classification.

Table 2-3 Waste generation by sector across the main states of Australia, 2002–03

State / Territory	Disposed *(tonnes)*				Recycled *(tonnes)*				Generated *(tonnes)*			
	Municipal	C&I	C&D	Total	Municipal	C&I	C&D	Total	Municipal	C&I	C&D	Total
NSW	2,170,000	2,831,000	1,340,000	6,341,000	1,156,000	1,365,000	3,309,000	5,830,000	3,326,000	4,196,000	4,649,000	12,171,000
Victoria	1,547,000	1,003,000	1,630,000	4,180,000	744,000	1,740,000	1,945,000	4,429,000	2,291,000	2,743,000	3,575,000	8,609,000
Qld	1,297,000	747,000	678,000	2,722,000	445,000	212,000	488,000	1,251,000[1]	1,742,000	959,000	1,166,000	3,973,000
WA[2]	741,000	420,000	1,535,000	2,696,000	92,000	324,000	410,000	826,000	833,000	744,000	1,945,000	3,522,000
SA	365,000	208,000	704,000	1,277,000	235,000	469,000	1,452,000	2,156,000[3]	600,000	677,000	2,156,000	3,433,000
ACT	82,000	98,000	27,000	207,000	29,000	52,000	223,000	467,000[4]	111,000	150,000	250,000	674,000
Total[5]	**6,202,000**	**5,307,000**	**5,914,000**	**17,423,000**	**2,701,000**	**4,162,000**	**7,827,000**	**14,959,000**	**8,903,000**	**9,469,000**	**13,741,000**	**32,382,000**

(1) The total recycling and generation figure for Queensland includes 105,000 tonnes of organics which is recycled by the private sector and not included in the waste sector quantities as the split is unknown.

(2) The disposal figures for WA are for metropolitan Perth. Recycling figures are not yet publicly available for WA, but have been provided by the Department of Environment (WA) for inclusion in this report.

(3) The total recycling figure for SA includes meat waste, a prescribed industrial waste.

(4) The total recycling figure for the ACT includes 163,000 tonnes of organics which is not included in the waste sector quantities as the split is unknown.

(5) There is currently no data available for Tasmania and the Northern Territory.

2.2.2 New South Wales

All NSW related data is drawn from the NSW DEC (2004) '*Waste Avoidance and Resource Recovery in NSW - A Progress Report*'. Figures showing total generation (disposal and recycling) and the diversion rate by material are presented in Table 2-4. Disposal, recovery, generation and diversion rate figures by material for the municipal, C&I and C&D streams are presented in Appendix 1.

Table 2-4 Disposal, recycling, generation and diversion rate by material, NSW 2002–03

Material	Disposed	Recycled	Generated	Diversion Rate
	Tonnes			Percent
Paper & cardboard	723,000	764,000	1,487,000	51%
Plastic	410,000	59,000	469,000	13%
Glass	109,000	171,000	280,000	61%
Ferrous	182,000	1,015,000	1,197,000	85%
Garden organics	735,500	842,000	1,577,500	53%
Food	750,500	45,500	796,000	6%
Timber	315,000	131,000	446,000	29%
Soil / Rubble	520,500	956,000	1,476,500	65%
Concrete	465,500	1,451,000	1,916,500	76%
Other recyclables(1)	67,000	395,000	462,000	85%
Other waste(2)	2,065,000	0	2,065,000	0%
Total	**6,341,000**	**5,828,500**	**12,172,500**	**48%**

(1) Comprises aluminium and other non-ferrous metals, liquid paper board, 'mixed hardcore' C&D waste and other C&D waste.

(2) Comprises mixed and contaminated waste not suitable for recycling, including asbestos and contaminated soil.

2.2.3 Victoria

Victorian data has been sourced from various Sustainability Victoria documents:

- '*Annual Survey of Victorian Recycling Industries 2002-2003*' (Sustainability Victoria 2004b)
- '*Local Government Data Collection 2002-2003*' (Sustainability Victoria 2004a)
- EPA Victoria landfill levy returns 2002-03

- ‘*Report on Waste Profile Study of Victorian Landfills*’ (Golder Associates 1999)
- ‘*Solid Industrial Waste Plan Data* Report’ (Sustainability Victoria 2002).

Disposal, recycling, generation and diversion rate figures by material are presented in Table 2-5. Appendix 1 provides disposal, recovery, generation and diversion rate figures by material for the municipal, C&I and C&D streams.

Table 2-5 Disposal, recycling, generation and diversion rate by material, Victoria 2002–03

Material	Disposed	Recycled	Generated	Diversion Rate
	Tonnes			Percent
Paper & cardboard	293,000	818,000	1,111,000	74%
Plastic	61,000	69,000	130,000	53%
Other plastic	115,000	0	115,000	0%
Glass	140,000	85,000	225,000	38%
Metals	211,000	971,000	1,182,000	82%
Food waste	723,000	22,000	745,000	3%
Garden organics	397,000	217,000	614,000	35%
Wood / Timber	457,000	169,000	626,000	27%
Other organics	93,000	141,000	234,000	60%
Clean excavated material	943,000	unknown	unknown	unknown
Concrete, bricks & asphalt	542,000	1,852,000	2,394,000	77%
Textiles	46,000	84,000	130,000	65%
Other	158,000	0	158,000	0%
Total	**4,181,000**	**4,429,000**	**8,607,000**	**51%**

2.2.4 Queensland

Queensland data has been drawn from ‘*The State of Waste and Recycling in Queensland 2003*’ (Queensland EPA 2004).

The total quantities of municipal, C&I and C&D waste disposed to landfill and recycled are presented in Table 2-6. Material based summaries for disposal and recycling from each waste stream are presented in Appendix 1 and highlight the lack of compositional data currently available for Queensland.

Table 2-6 Disposal, recycling, generation and diversion rate by sector, Queensland 2002–03

Sector	Disposed	Recycled	Generated	Diversion Rate
	Tonnes			Percent
Municipal	1,297,000	445,000	1,742,000	12%
C&I	747,000	212,000	959,000	22%
C&D	678,000	488,000	1,166,000	42%
Total	**2,722,000**	**1,250,000[1]**	**3,973,000**	**31%**

[1] The total recycling and generation figure for Queensland includes 105,000 tonnes of organics which is recycled by the private sector and not included in the waste sector quantities as the split is unknown.

No compositional data for materials disposed to landfill are available for Queensland. Compositional figures for material disposed to landfill from the municipal sector have been calculated by deducting household recycling quantities from the total consumption and are presented in Appendix 1.

Although more detailed composition information was given in the original source data, plastics have been taken to include: PET, HDPE, PVC and polypropylene. In addition, the paper and cardboard group is taken to include liquid paperboard.

There is no compositional data available for materials disposed and recycled from the C&I or C&D sector for Queensland.

Some information on organic wastes was available but as the data was not split between the waste streams it was not able to be included within this compilation.

2.2.5 Western Australia

There is little readily available information for Western Australia in terms of waste disposal. For this report, data on waste disposed to landfill from the municipal, C&I and C&D sectors has been gathered through personal communication with the WA EPA.

No compositional data for materials disposed to landfill are available for Western Australia. To determine the composition of garbage disposed to landfill from the municipal sector, compositional data was used from a study conducted by Murdoch University in 1999 for the City of Stirling (cited in WMB 2003).

Data on recycling activity in Western Australia has been drawn from a recent study commissioned by the Department of Environment (WA), not yet publicly available. This study involved carrying out a survey on the level of material recovery and reprocessing activity provided by the Western Australian recycling industry over the 2004–2005 financial year, including determining the composition of material recycled from the municipal, C&I and C&D sectors. The data sets a baseline on the current quantities of materials being recycled in Western Australia, a first for Western Australia.

Quantities of municipal, C&I and C&D waste to landfill and recycled are provided in Table 2-7. Material based summaries for disposal and recycling from each waste stream are presented in Appendix 1 and highlight the lack of landfill compositional data currently available for Western Australia.

Table 2-7 Disposal, recycling, generation and diversion rate by sector, WA 2002–03

Sector	Disposed[1]	Recycled	Generated	Diversion Rate
	Tonnes			Percent
Municipal	741,000	92,000	833,000	11%
C&I	420,000	324,000	744,000	43%
C&D	1,535,000	410,000	1,945,000	21%
Total	**2,696,000**	**826,000**	**3,522,000**	**23%**

(1) The disposal figures for WA are for metropolitan Perth.

2.2.6 South Australia

The total quantity of waste disposed to landfill for South Australia is derived from data collected by the SA EPA.

The split between the three waste streams - municipal (27.5%), C&I (15.7%) and C&D (53.1%) - was determined through a landfill audit conducted by SA EPA in 1998; '*South Australia: Landfill Audit. Government of South Australia EPA*' (2000).

The '*Consultancy Report: Survey and audit of kerbside waste and recycling practices*' (SA EPA 2002) was used to calculate the municipal disposal composition.

The composition of C&I and C&D waste disposed to landfill was taken from the '*Landfill Survey Zero Waste South Australia*' conducted in June 2004 (Zero Waste SA 2004).

All recycling data, including the split between the municipal, C&I and C&D waste streams, is drawn from the report '*Review of Recycling Activity in South Australia Stage 1 - Quantification of Future Expansion Priorities*', prepared for Zero Waste SA by Nolan-ITU in 2004.

Disposal, recycling, generation and diversion rate figures by material are presented in Table 2-8. Material based summaries for disposal and recycling from the municipal, C&I and C&D waste streams are presented in Appendix 1.

Table 2-8 **Disposal, recycling, generation and diversion rate by sector, SA 2002–03**

Material	Disposed	Recycled	Generated	Diversion Rate
	Tonnes			Percent
Paper	73,000	136,000	209,000	65%
Plastics	73,000	15,000	470,000	84%
Steel		304,000		
Aluminium		19,000		
Non-ferrous metals (ex. Aluminium)		13,000		
Glass		46,000		
Concrete	13,000	875,000	888,000	99%
Brick & tile / Rubble & soil	681,000	327,000	1,008,000	32%
Asphalt	4,000	100,000	104,000	96%
Timber	20,000	116,000	136,000	85%
Garden organics	92,000	127,000	219,000	58%
Food organics[1]	137,000	74,000	211,000	35%
Textiles	6,000	4,000	10,000	40%
Rubber	8,000	100	8,100	1%
Other waste[2]	170,000	0	170,000	0%
Total	**1,277,000**	**136,000**	**3,433,100**	**63%**

(1) Includes meat waste.

(2) Includes dry-cell batteries, household chemicals, pharmaceuticals, medical / hygiene, oil (motor and food), timber, ceramics, textiles, other glass and broken glass.

2.2.7 Australian Capital Territory

All disposal and recycling figures were derived from the NoWaste ACT website. C&I recovery was calculated as the difference between total recovery and kerbside household recycling and demolition waste recycling figures. Quantities of municipal, C&I and C&D waste to landfill and recycled are provided in Table 2-7.

Material based disposal, recycling and generation figures by sector for the ACT are presented in Appendix 1 and highlight the lack of available data on the composition of materials recycled from the C&I and C&D waste streams.

The municipal garbage composition was drawn from the results of a kerbside waste and recycling audit conducted in April 2004 (ACT JRG & ACT NoWaste 2004).

The composition of C&I and C&D waste disposed to landfill is based on the ACT Waste Inventory completed in May 1997, presented in '*The Next Step in the No Waste Strategy*' (ACT No Waste 2000).

Table 2-9 Disposal, recycling, generation and diversion rate by sector, ACT 2002–03

Sector	Disposed	Recycled	Generated	Diversion Rate
	Tonnes			Percent
Municipal	82,000	29,000	111,000	26%
C&I	98,000	52,000	150,000	35%
C&D	27,000	223,000	250,000	89%
Total	**207,000**	**467,000**	**674,000**	**69%**

2.3 Products

There is limited national and state data available on the consumption and recycling of products. Table 2-17 lists 50 significant products identified in the market place and their estimated diversion rate from landfill:

- Low: less than 20%
- Medium: 20% – 50%
- High: greater than 50%

Estimates of recycling are based on data from material recycling surveys undertaken by state agencies and industry associations.

Table 2-10 Degree of recycling for 50 significant products identified in the market place

	Estimate on current degree of recycling in Australia
APPLIANCE PRODUCTS	
Fixed Line Phones	None
Heaters	Low
Hot Water Systems	Medium
Mobile Phones	Low
Power Tools	Low
Small Appliances	Medium
Televisions	None
White Goods	High
CONSUMER PRODUCTS	
Books	Low
CD Media	None
Clothing	Medium
DVD Media	None
Footwear	Low
Gas Cylinders	Medium
Mattresses	Low
Newspapers	High
Phone Books	High
Toys	None
Video Cassettes	None
ELECTRICAL & ELECTRONIC PRODUCTS	
Computers	Low

	Estimate on current degree of recycling in Australia
Fluorescent Tubes	Low
NiCad Batteries	Low
Personal Batteries	None
Printer & Computer Peripherals	None
Smoke Detectors	None
Video & Stereo Electronic Peripherals	None
PACKAGING PRODUCTS	
Beverage Packaging	High
Flexible Plastic Freight Packaging	Medium
Food Packaging	Medium
Freight Packaging Pallets	High
Other Grocery Packaging	Low
Retail Carry Bags	Low
AUTOMOTIVE PRODUCTS	
Automotive Batteries	High
Cars	High
Tyres	Low
BUILDING MATERIALS	
Asphalt Road Materials	Low
Bricks	Medium
Cables	High
Carpet	Low
Concrete Paving & Construction	High
Wire Fencing	High
Insulation	None
Office Fittings	Low
Paint & Paint Packaging	Low
Piping	Low
Roofing Iron	High
Roofing Tiles	Medium
Structural Timber	High
Treated Timber	None
Window Glass	Low

2.4 Trends

2.4.1 Historical

There is limited historic data available on the quantity and composition of materials recycled throughout Australia. It is, therefore, not possible to accurately determine trends across Australia from ten years ago.

Changes in landfill and recycling quantities between 1993 and 2002–03 in metropolitan Sydney, Victoria and the ACT are presented to give an indication of the trends (see Table 2-11).

Over the last decade total waste generation in metropolitan Sydney has increased by 161 percent. As evident from Table 2-11, the total quantity of waste disposed to landfill has increased from 3.2 to 4.2 million tonnes, an increase of 31 percent. During the same period recycling quantities have increased dramatically.

Waste generation in Victoria has also increased. Since 1993, Victoria's solid waste stream has increased by 78 percent, reaching 8.6 million tonnes in 2002–03. This increase most closely matches the growth in recycled material, which has grown tremendously from 1.3 to 4.4 million tonnes. Over this same time period, the quantity of material disposed to landfill has remained relatively stable.

In the ACT total waste generation has increased by 26 percent since 1993. This increase is due to a significant growth in recycling, more than tripling in quantity. Waste disposed to landfill, by contrast, has fallen from 0.4 to 0.2 million tonnes.

Table 2-11. Changes in waste generation between 1993 and 2002–03 (tonnes).

		1993	2002–03	% Change
Sydney	*Waste to landfill*	3,175,000(1)	4,151,000(3)	+31%
	Waste recycled	201,000(2)	4,675,000(3)	+2,223%
	Total	***3,376,000***	***8,826,000***	***+161%***
Victoria	*Waste to landfill*	4,067,000(4)	4,181,000(6)	+3%
	Waste recycled	1,283,000(5)	4,429,000(6)	+245%
	Total	***5,350,000***	***8,611,000***	***+61%***
ACT(7)	*Waste to landfill*	416,000	207,000	-50%
	Waste recycled	118,000	467,000	+295%
	Total	***534,000***	***674,000***	***+26%***

(1) NSW EPA (1999); Nolan-ITU (1998); various Regional Waste Plans and updates (1996 – 2000)
(2) NSW EPA (2003)
(3) NSW DEC (2004)
(4) Sustainability Victoria (2005)
(5) Sustainability Victoria (2004b)
(6) Sustainability Victoria (2004b); Sustainability Victoria (2004a); Golder Associates (1999); Sustainability Victoria (2002) and Victoria EPA Landfill levy returns 2002-03
(7) ACT NoWaste (2005)

The past decade has been characterised by tremendous growth in recycling across Australia. In addition to the expansion of recycling that has occurred in NSW, Victoria and the ACT, recycling volumes have also grown dramatically in Qld, WA, and in particular SA.

Initially the growth was linked to the establishment, expansion and upgrading of household kerbside recycling systems. The upgrading of kerbside systems has included increased frequency of collection, better collection containers and a wider range of materials/products collected.

Evolving from collections of newspapers, aluminium cans and glass bottles over 20 years ago, the addition of packaging cardboard, office paper, steel and plastic containers has resulted in a broader range of material collected along with improving recovery yields as systems mature. There has been no significant expansion to the range of materials collected in the past five to eight years.

Over the past five to ten years there has also been enormous growth in recycling of materials from the building construction and demolition industry. This has been strongest in Melbourne, Adelaide and Sydney. The past ten years has seen the commencement of recycling of materials such as asphalt and timber together with major increases in concrete and metal recycling.

2.4.2 Projected

Projections of future disposal and recycling quantities were calculated for 2012–13 and 2022–23. The increases are based on an average annual per capita GDP growth of 1.88 percent and an average annual population growth of 1.13 percent. This is in accordance with the methodology used in the '*Regulatory Impact Statement (RIS) on the Revised National Packaging Covenant*' prepared by Nolan-ITU for the Environment Protection and Heritage Council in 2005. The projections assume that no changes in the proportion of materials recovered will occur.

It is, however, likely that the trend of the past ten years where recycling activity has expanded will continue. Many kerbside recycling systems are now at a mature level and large gains are unlikely. Similarly, the prospect for further major gains in metals, concrete and cardboard recycling is limited. On the other hand there is likely to be significant expansion of commercial and industrial recycling and large gains in construction and demolition recycling markets such as Qld and WA.

Table 2-12. Projected disposal and recycling quantities in Australia.

Sector	2002–03			2012–13			2022–23		
	Disposal	Recycling	Total generation	Disposal	Recycling	Total generation	Disposal	Recycling	Total generation
	Tonnes								
Municipal	6,045,000	2,408,000	8,451,000	8,148,000	3,246,000	11,392,000	10,984,000	4,376,000	15,357,000
C&I	5,308,000	3,837,000	9,144,000	7,155,000	5,172,000	12,326,000	9,645,000	6,972,000	16,615,000
C&D	5,918,000	7,417,000	13,331,000	7,977,000	9,998,000	17,971,000	10,753,000	13,477,000	24,225,000
Total	17,429,000	14,217,000	31,640,000	23,494,000	19,164,000	42,651,000	31,670,000	25,833,000	57,493,000

2.5 Commentary on methodology and limitations

Currently, data availability, quality, and timeliness on waste and recycling varies widely between the States/Territories. Some states do not provide sufficient information on all wastes disposed and diverted from landfill in their jurisdictions. Further, the data which is collected is often not directly comparable between all States/Territories. Different data collection methodologies and reported material types are being used throughout Australia.

Landfill

In general, across Australia, there is a considerable amount of information available on the total quantity and composition of wastes disposed to landfills. Some of this information is based on estimates, particularly in regional Australia where many landfills operate without weighbridges.

There is, however, a lack of detailed compositional data on waste materials sent to landfill, with the exception of NSW, Victoria and SA. The largest data gaps exist for the C&I waste stream. In addition, little is known about the quantities and characteristics of hazardous materials contained in waste streams.

Recycling

There is less published data available on the quantity and composition of materials diverted from landfill for recycling across Australia.

Comparative kerbside recycling data across Australia is available through the *National Environmental Protection (Used Packaging Materials) Measure* which requires each state to report annually on household kerbside recycling. Whilst it is a legislative requirement of each jurisdiction to report against NEPM, not all Local Governments across Australia respond to their State/Territory survey. Further, the scope of the survey is limited to household recyclables collected at the kerbside by local government and does not capture all municipal waste diverted from landfill, such as clothing donated to charities that are converted into rags, metals sold directly to the local scrap metal dealer and garden organics dropped off at the reprocessors gate for composting.

More data gaps exist with regard to the quantity and composition of materials that are sourced from the C&I and C&D sector for recycling.

No standard methodology exists for the collection of total recycling activity across Australia. Nevertheless, NSW, Victoria, SA, and WA are using a similar methodology for determining current levels of recycling activity in their jurisdictions. This enables broad comparisons and benchmarking to be made on the level of recycling activity across these states with a sufficient degree of confidence that the results will be meaningful.

Nonetheless, care should always be taken when comparing data sets between jurisdictions as categories of waste materials reported against vary, as do response rates by industry players.

Most data collected and collated on recycling activity is provided on a voluntary basis and therefore needs to have support of industry players to provide a response. Concerns over commercial sensitivity of data, particularly in relation to industry data, can impact the result. To overcome this, some data is only made available in aggregate. This is particularly the case where there exists a small number of players (such as at the state level). As a result, data can end up highly aggregated, making comparisons on recycling at the material level between jurisdictions difficult.

A brief commentary on the various methodologies used to derive waste information in the States/Territories is provided below.

2.5.1 New South Wales

In NSW, figures on waste disposal are collected and collated by the NSW Department of Environment and Conservation (DEC) through the disposal levy scheme. In addition, the DEC and councils work cooperatively to provide figures on kerbside recycling and organics collection and processing. Information on C&I and C&D recycling activities is also collated by the DEC which continues to undertake a number of projects to improve knowledge about the various waste and recycling streams from the non-municipal sector. The most recent 'progress report' (NSW DEC 2004) provides a concise summary of waste disposal and recycling quantities and composition for both metropolitan Sydney and the whole of NSW.

2.5.2 Victoria

Landfills located in Victoria that service a population of 5,000 people or greater are subject to EPA Victoria licensing provisions. The Environment Protection Act 1970 requires a landfill licence holder to pay a levy for each tonne of waste deposited. Collection of the landfill levy by the EPA Victoria provides data on the amount and source sector of waste disposed to licensed landfills.

In Victoria, most of the recycling data available is collected and collated by Sustainability Victoria (formerly EcoRecycle Victoria). As part of Sustainability Victoria's ongoing data collection and performance management program, statistical information is collected annually on the:

- Waste and recycling services provided by all Victorian local councils, producing a report called *Local Government Data Collection*.
- Level of recycling activity in Victoria (by surveying Victoria's reprocessors of secondary-use materials), producing a report called the *Annual Survey of Victorian Reprocessing Industries*.

Sustainability Victoria also gathers data about waste and recycling for various products and industry sectors, as well as litter measurement, to improve knowledge and establish benchmarks for improving Victoria's waste management services.

There have also been a number of kerbside waste and recycling and disposal based landfill audits conducted in Victoria that provide a snapshot of the composition of the waste stream in Victoria.

2.5.3 Queensland

Data available in the '*State of Waste and Recycling in Queensland 2003*' report (Queensland EPA 2004) is based on data obtained from:

- Local government in Queensland
- Private waste and recycling contractors
- Composters' reports via surveys.

However, waste generation data and landfill quantities were calculated based on generation and recovery figures drawn from national estimates. Another issue is the organic waste stream which is provided as an aggregate, with no allocation between municipal, C&I and C&D waste and recycling streams.

2.5.4 Western Australia

The waste composition for Western Australia was based on a Murdoch University study undertaken in 1999 giving an average composition for household mobile garbage bins in the City of Stirling. It is therefore out dated and not necessarily representative for all of Western Australia.

2.5.5 South Australia

Nolan-ITU and Waste Audit conducted comprehensive telephone surveys of collection methods along with an analysis of drop off facilities for the '*Consultancy Report: Survey and Audit of Kerbside Waste and Recycling Practices*' (SA EPA 2002). Further, physical audits were undertaken in all metropolitan and in six non-metropolitan council areas to identify the composition of the waste and recycling streams.

2.5.6 Australian Capital Territory

The ACT recycling data is presented by ACT NoWaste as an aggregated total on a material basis, with the exception of demolition materials which were grouped together as an aggregated total. There is no similar aggregated information for waste generated from the C&I sector. Hence it was necessary to calculate C&I waste quantities based on available data for inclusion in this report. The garbage composition used for the ACT was drawn from the audit results presented in the '*Canberra Residential Waste Audit*' (ACT JRG & ACT NoWaste) conducted in April 2004. No compositional data for materials recycled from the C&I and C&D sector was available.

2.6 International data on waste generation and management

In looking at international methods of data management a key questions is 'What countries collect and use data on waste more effectively than we do and what are the lessons for Australia?'

2.6.1 Data management

Individual Countries

In Europe, for example, the situation regarding data management and availability illustrates polar opposites. Some countries have comprehensive and reliable information, which is regularly updated (e.g. Austria, Switzerland and Germany). In contrast, other countries (almost all of the ten New Member States) do not have accurate information and base their waste estimates on population statistics and economic indicators which usually results in a poor reflection of real waste flows.

Austria is taken as an example to briefly discuss some of the key features of good waste data "collection methodologies". It is generally recognised as one of the countries with the best data on waste management and resource recovery. Reliable and accurate time series data is available for major waste streams for over three decades.

Data on wastes disposed for both municipal and non-municipal streams (including wastes processed prior to disposal), is collected by Regional Council Groups and/or States depending on who controls these types of facilities. Once collected, data is collated on a State basis and passed on to the Federal Environment Agency (Umweltbundesamt), in accordance with the National Waste Management Plan [1].

Much more complex is the acquisition and verification of the data for the approximately 50% of wastes (by weight) which are collected and managed/processed separately.

Quantities and types of organic wastes segregated at source for collection and processing are provided by councils to the relevant State environment agencies for collation and verification prior to publication by the Federal Environment Agency.

Quantities of municipal recyclables are reported through the collectors. In addition, operators of sorting, beneficiation and reprocessing facilities are

[1] Austrian Waste Management Act 1992, requiring a Waste Management Plan being updated every three years.

obliged to report quantities of all recyclable materials (including municipal) processed. Not all of these obligations are legally enforced or enforceable, however, the network of reporting mechanisms, licensing regimes, corporate reporting activities and financial incentives ensures constant and accurate flow of information. A good example of accurate and ‘real time’ data flow is for packaging materials under the Austrian Packaging Ordinance where all participating organisations are bound to report regularly. For packaging and most other areas of recycling, data is usually collected and collated on a national basis through the Federal Environment Agency with the assistance of consultants.

Table 2-13 provides a simplified summary of waste data collection in Austria. In addition to undertaking the work required on the complex collection of recycling data on non-municipal streams, a Section in the Federal Environment Agency collates all information and reports regularly on national waste and recycling data. This involves no more than two or three dedicated Government officials in association with a handful of experienced and specialised consultants.

Table 2-13 Simplified waste data collection, Austria

	Disposal	Recycling
Municipal	Regional Groups	Regional Groups
Non-Municipal	Regional Groups/States	Federal EPA plus consultants

European/OECD level

Waste statistics in Europe are collected through a questionnaire developed jointly by Eurostat and the OECD, which is referred to as the Eurostat/OECD Joint Questionnaire (JQ). The questionnaire is sent to participating countries every second (even) year and seeks annual data on waste generation, waste treatment and waste management infrastructure. To date, the JQ has been the only standardised source for international waste data. The JQ data builds the basis for the indicator set on municipal waste that is part of the set of Structural Indicators designed to measure the success or failure of EU policies and is published every year.

One of the most comprehensive documents on waste generation and management has recently been produced by EUROSTAT (2005). The collection, compilation and interpretation of data is undertaken by a mix of consultants and officials under the management of the Department for Environment Statistics.

Starting with 2004 as the first reference year, the Waste Statistics Regulation (European Parliament and the Council of the European Union 2002) will replace the Joint Questionnaire as the main data source for the EU. The Waste Statistics Regulation requires the EU Member States to report data on waste generation, waste treatment and waste treatment infrastructure for every even year. The Regulation is expected to considerably improve data availability as well as quality and comparability.

The publication of first results on the basis of the Waste Statistics Regulation can be expected by the beginning of 2007.

To enable comparison, waste generation is presented in relation to the country population (kg/person) and to the sectoral Gross Value Added[2] (kg/1 000 EUR GVA).

Less consistent, and therefore much more limited on a European level, is information on recycling. Consistent information is usually available for municipal recycling and packaging. For all other recycling activities and material streams, published data is heterogeneous and rarely provides the full picture.

In summary, waste disposal information is comprehensive albeit not necessarily accurate for all member countries. Recycling data is improving but still inconsistent and lacks detail in parts.

2.6.2 Policy

In considering the question 'How do countries with good waste and recycling data use this data better than Australia?'. The following response is provided:

1 It is commonly good waste policy that requires reliable and accurate information in the first place.

2 There is a growing need to establish this information as part of international obligations.

A number of multilateral agreements are in place which cannot be honoured without good information on waste flows through national economies. These include several import/export agreements on certain materials. However, the strongest drivers are binding targets on waste reduction and reduction of organic materials disposed to landfill. Here, European legislation (the best known being the Landfill Directive) is being implemented in member countries. Despite different time frames and phases, all targets are legally binding and require sound data bases for the purposes of infrastructure and financial planning as well as reporting against compulsory targets.

3 The "effective use" of such information is hard to ascertain without first defining what "effective" means in the context of waste management and resource recovery. Indeed, the policy of a country

[2] Gross Value Added (GVA) is the net result of output valued at basic prices less intermediate consumption valued at purchasers' prices. Gross value added is calculated before consumption of fixed capital. It is equal to the difference between economic output and intermediate consumption. Concerning the differentiation between GDP (Gross Domestic Product) and GVA, note that from an "output" point of view, GDP is made up by the following components: GDP = GVA + Taxes - Subsidies on products - FISIM (Financial Intermediation Services Indirectly Measured).

will have to define what the desirable goals are. Then, progress and efficiency can be measured against these goals.

In general, leading countries have adopted the following principles:

- Continuous improvement of resource efficiency
- More sustainable production and consumption patterns
- Decoupling economic growth from waste generation and environmental impacts.

Germany was one of the first countries to publish progress in the "dematerialisation of the economy". Figure 2-1 illustrates how waste generation in Germany has reduced per unit of GDP over a period of four years[3].

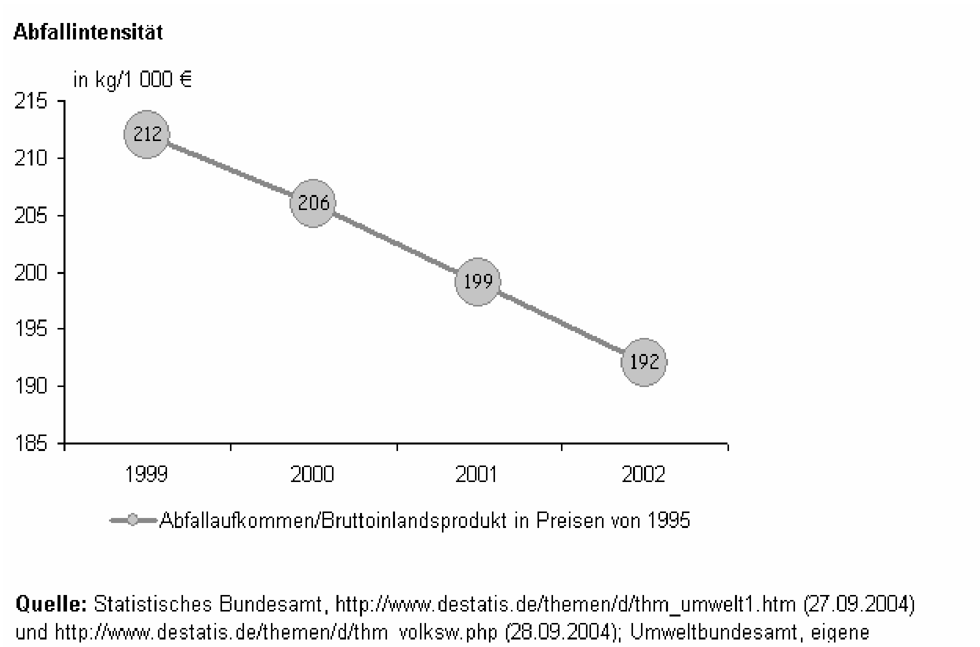


Figure 2-1 German waste generation in kilograms per 1,000 Euro of gross domestic product (German National Department of Statistics 2004)

[3] Note that this period was also prior to the slowing down of the German economy in more recent times.

2.7 Conclusions

In assessing current waste and recycling data, the following conclusions are made.

2.7.1 Key data gaps

The major gaps in waste and recycling data are the:

- lack of data on product and material consumption within Australia
- lack of data on product use life expectancy and the flow of materials through product life
- lack of data on waste disposal in Tasmania, Northern Territory and non-metropolitan Western Australia
- lack of data on recycling in Tasmania and the Northern Territory
- failure to link waste generation levels to economic growth and to identify any 'dematerialisation of the economy'.

2.7.2 Key methodology issues

The major issues in data methodology are the:

- inconsistency of data collection at a state level
- need for data to be disaggregated by source sectors and product (where possible)
- inconsistency of methodology by industry organisation in relation to materials and/or products.

The lack of consistent methodology for waste and recycling makes benchmarking of resource use, recycling and waste disposal performance within Australia and internationally generally not possible.

It is also important that data be linked to policy priorities and program expenditure.

3 The environmental impact of waste management

3.1 Introduction

Understanding the environmental impact of waste management has emerged as a research priority for environmental policy decision making throughout the OECD over the past five to ten years (EU European Union, 6th Environmental Action Plan 2004; USEPA1998; UK Environment Agency 1998). As the environmental policy goal shifted from one of "environmental protection" to "sustainable economic development", a systems-based approach to impact assessment was required in addition to more traditional site-based assessments. New assessment tools emerged to quantitatively measure the relative environmental performance of goods and services, as well as policy and technology options.

Systems-based impact assessment is consistent with an economic framework, in that, economic activity is measured by its physical throughput, or "materiality", using materials accounting tools. Rather than tally transaction costs across the life cycle of a product to derive price, materials accounting tools are used to tally all resource inputs and pollution and waste outputs. An inventory of such input and output loads is a quantitative measure of the *materiality* of goods and services, or policy and technology options. The internationally standardised tool for this assessment is Life Cycle Assessment (ISO 14040). Other quantitative assessment tools include substance and materials flow analysis and materials accounts (measure material flows through regions or economic sectors).

Consistent with an economic viewpoint, environmental impact:

- is correlated with the material or physical throughput of the economy (Rodrigues 2004)
- exists as a symptom of "market failure" (Pearce 1990) caused when markets fail to properly cost environmental services (thus giving rise to environmental externalities).

3.2 Summary of impacts from integrated waste management

The goal of sustainable resource use requires that policy objectives in integrated waste management be established based on an understanding of the environmental impact of waste management options.

Environmental impacts associated with the generation and disposal of waste may include resource use impacts and emissions to air, land and water (including greenhouse gas emissions). These arise at each stage in the life cycle of the waste management service and include collection, sorting, processing, transport of goods, as well as final disposal to landfill.

During the past decade, local and international studies have identified the *materiality*, or net input/output load of waste management options, including landfill and alternative waste technologies (AWT), such as incineration, new thermal technologies and Mechanical Biological Treatment, as well as recycling of commodities and various materials recovery strategies. Traditional methods of interpreting the environmental significance of the net material load have been largely scientific and originated in academia (CML 1998, 2000; PRE 1999). These approaches have progressed considerably over the past decade as a result of the international debate caused by development of an international standard for Life Cycle Impact Assessment (ISO 14042) and also by an increasing demand for policy support and the associated availability of research funds.

Another approach used for interpreting the material load data is Environmental Economic Valuation. The development of these approaches has enabled the results of Life Cycle Assessment (LCA) studies to be more meaningful to more people. This approach has proved popular and has enabled decision making to tap into the vast amount of science and engineering data required for system based assessment.

3.3 Integrated waste management options - Externalities

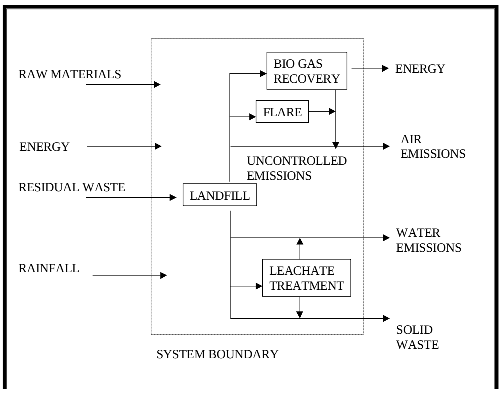
From an economic viewpoint, if the aim of society is maximising the sum of benefits from production minus the sum of costs, there is policy value in attempting to identify and define costs. Increasingly in policy-making in Australia, as throughout the developed world, the externalised environmental costs are being systematically calculated and factored into the decision making process (European Commission 2000; OECD 2001; Eunomia 2003).

Only by understanding the physical input/output of systems and the corresponding environmental significance of this input/output inventory, can the environmentally optimal solution be found.

The externalities associated with various integrated waste management options have been calculated during the past decade by the consulting firm Nolan-ITU and by the RMIT Centre for Design. The approach used is illustrated in Figure 3-2.

Externality values of waste management are summarised in Table 3-14. Environmental impacts have been identified using Life Cycle Assessment and valued in monetary terms using the Nolan-ITU Environmental Economic Valuation model.

Step 1: System Characterisation (e.g. simplified landfill)



Step 2: Input/Output Analysis (e.g. simplified inventory data for various landfill stages)

I/O - LCA (Inventory Analysis)

FUEL IMPACT DATA (production and use)			
	Petrol	Diesel	Electricity
	per 1000 litre	per 1000 litres	per MWh
ENERGY (GJ)	42	44.1	9.5
INPUTS			
SOLID			
WASTE			
non-haz (t)	0.0053	0.0057	0.0491
AIR			
EMISSIONS			
(g)			
Particulates	2446	2564	249.84
CO	25323	26548	116.64
CO2	2491318	3036258	914400
CH4			0
NOx	32301	33901	2386.8
N2O		41	8.1
SOx	9640	10106	3.996
HCl	36	38	0.00252
HF	36	38	0
H2S			0.000018792
HC	10395	10898	2.0592E-06
Chlor. HC			0.0093024
Diox/Furans			2.628E-12
NH3			0
As			0.10872
Cd			2.1456E-06
Cr			0.00702
Cu			0.09216
Pb	144		0.4464
Hg			0.010512

LANDFILL GAS COMPOSITION (g/Nm3)		
ENERGY (GJ)		
INPUTS		
SOLID WASTE		
	Landfill Gas	Flare/Engine Exhaust
(g)		
Partics.		0.0043
CO	0.0125	0.8
CO2	883.93	1964.29
CH4	392.86	0
NOx		0.1
N2O		
SOx		0.025
HCl	0.065	0.012
HF	0.013	0.000021
H2S	0.2	0.00033
HC	2	0.06
Chlor. HC	0.035	0.01
Diox/Furans		8E-10
NH3		
As		
Cd	0.0000056	9.4E-[illegible]
Cr	0.00000066	1.1E-0[illegible]
Cu		

Step 3: Environmental Economic Valuation combined with I/O load

ENERGY (GJ)		
INPUTS		
SOLID WASTE		
	Pollutant Load	Valuation Data ($/kg)
AIR POLLUTION		
(g)		
Particulates.	0.0743	$9.40
CO	0.0825	$0.03
CO2	983.93	$0.00
CH4	992.86	$0.96
NOx		$3.82
N2O		$0.00
SOx	0.025	$0.44
HCl	9.065	$9.16
HF	0.013	$9.16
H2S	30.2	$44.05
HC	22	$0.96

Pollutant Load (g/function)

Valuation Data ($/g)

Figure 3-2 Externality valuation of waste management – the Approach

Table 3-14 Environmental valuation summary for integrated waste management options

Waste Activity	Approximate Environmental Balance (Eco$/t)(1)	Reference
Landfill of MSW	–200 to –400(2)	National Packaging Covenant Council (2001): Independent Assessment of Kerbside Recycling in Australia. Global Renewables Limited National Benefits Study (Nolan-ITU, 2004)
AWT Stabilisation (MBT and WTE)	> +100(3)	RMIT & Nolan-ITU (2003): Life Cycle Assessment of Waste Management Options in Victoria. NSW DEC (2004): Getting more from our recycling Systems – Assessment of Domestic Waste and Recycling Systems
Commodity Recycling (basket)	+ 400	National Packaging Covenant Council (2001): Independent Assessment of Kerbside Recycling in Australia.
Garden Organics Recycling	> +120	NSW DEC (2005): TBL Assessment of Garden Organics Management

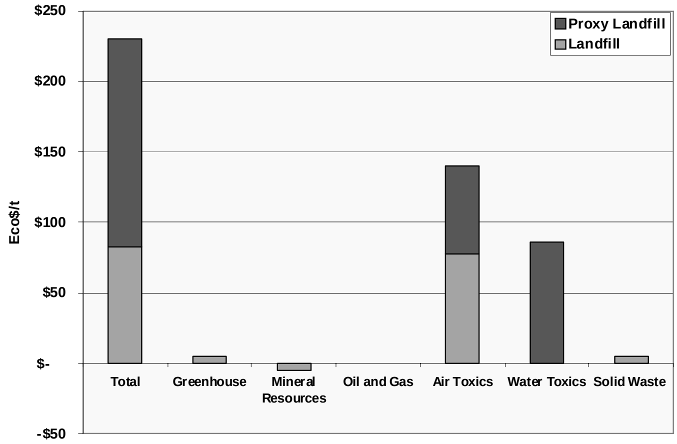
(1) Avoided landfill benefits are included in benefit assessment for all landfill alternatives above. Note: Landfilling of dry recyclables simplified to assume no emissions to air or water.

(2) Partial valuation only due to limited scope.

(3) Extended LCA and environmental economic modelling not available previously.

It is noted that all studies from which environmental values ("Ecodollars") have been derived were undertaken for a specific purpose and have their limitations and qualifications. All values given are based on a limited range of pollutants and are based on conservative estimates. A summary of the valuation approach is provided in Appendix 2.

Landfill LCA and valuation is provided as a wide range of externality costs as it has not been studied or publicly reported on in Australia (assumptions are summarised in Appendix 2). Nolan-ITU has modelled landfill impacts for studies on packaging and organics management and AWT processing. Deficient data was recently highlighted by the inclusion of proxy values calculated based on European data (DEC 2004).



It is noted that there are additional impacts of waste management including the effects of littering (Clean Up Australia 2004) and illegal dumping. The environmental impacts of these activities include injuries and death to marine life, release of pollutants to soils and water as well as 'social' impacts such as the loss of visual amenity.

4 Barriers to resource recovery in Australia

There are numerous political, economic, social, technological, environmental, legal and institutional barriers to the improvement of resource recovery in Australia. While it is beyond the scope of this short paper to fully identify, quantify and prioritise these barriers, several key ones are discussed below.

Several aspects should be borne in mind when considering the discussion below. First, it is presumed here that increased resource recovery levels are desirable due to the environmental and social benefits that they deliver. Secondly, it is presumed that the optimal point of resource recovery in Australia has not yet been reached. Thirdly, the reality is that different barriers apply in different measure to different materials and products; the discussion here is necessarily of a generalist nature. Finally, it is noted that much of the discussion presented here is not “new” to the public policy debate in Australia. Many of the points below have been regularly raised by different commentators from the mid 1990’s onwards.

4.1 Resource Pricing

Pricing structures and signals strongly affect resource recovery in Australia.

As a result, resource recovery levels tend to be higher and more sustainable for materials and products where:

- The price of the recyclate material compares favourably to the price of the competing non-recyclate (or virgin) material;
- As a result of the above factor, there is a clear profit to be made from the sale of the recyclate material following the cost of the material’s collection and reprocessing; and/or
- There is a strong market demand for the recyclate material.

Conversely, resource recovery levels tend to be lower and less sustainable for materials and products where:

- The price of the recyclate material does not compare favourably to the price of the competing non-recyclate (or virgin) material;
- There is limited market demand for the recyclate material;
- As a result of the above factors, the price paid for the recyclate material does not necessarily meet the cost of the material’s collection and reprocessing; and
- Forms of subsidisation are necessary to fund the gap between the price of the recyclate material’s sale and the cost of the material’s collection and reprocessing.

Plastics are notable in the above regards, as are computers, televisions, white goods, batteries, tyres, and other materials and products.

The recovery and utilisation of printing and writing paper in Australia is a clear example of how comparative pricing influences recovery. Most of this grade of paper is recycled in to packaging in Australia rather than higher grades (such as tissue or back into printing and writing paper) because the costs of collection and sorting are much less when mixed grades are collected. This is despite the high environmental credits that would be delivered if bleached virgin pulp was displaced by the recycled substitute pulp.

Mixed paper is collected either from kerbside or commercial sources. This grade has less predictable performance characteristics than sorted office papers and therefore attract a lower market price. For higher grade recovery of printing and writing papers, the cost of the required collection, contaminant screening and de-inking of the recycled fibres, means that virgin pulp is cost competitive at US $ 400 per tonne. The market for recyclable paper materials is generally linked to the USA commodity price and consequently has always fluctuated dramatically for spot market traders, ranging from an upper level of US $400 per tonne waste down to $5 per tonne for post-consumer mixed papers.

There are several reasons why the price of a recyclate material may not compare favourably to the price of a competing non-recyclate (or virgin) material. These include:

- **Technical efficiency**. Virgin resource extraction and refining activities have economies of scale beyond those possible in the collection and reprocessing of secondary materials. Often, there is a level of technological and engineering complexity that adds to cost. Equally, because the overall market for the recyclate material tends to be emerging and smaller, there can be less than optimal investment and innovation in technological and engineering processes.

This is the case for most commodity materials. For some materials, such as aluminium and steel, the sorting and collection stages reduce the cost competitiveness of the material most notably. For other materials there are added complications in the reprocessing stages – plastics are an example here, particularly PET bottles when recycled back into PET bottles due to contamination issues.

- **Quality**. The quality of the non-recyclate (or virgin) material may be superior to that of the recyclate material or better conforms to manufacturers' specifications and requirements.

This is typically the case where structural performance (building materials such as recycled concrete) or food grade quality is required (plastics in food packaging).

- **Subsidies**. The production and supply of the non-recyclate (or virgin) material benefit from some form of direct or indirect public subsidisation. In 1996, it was estimated that the cost of direct financial subsidies to natural resources in Australia in 1994 to be $5.7 billion per year (Department of Environment Sport and Territories 1996). Direct subsidies include low access fees, tax treatment and public agency costs subsidisation. In this respect, the Industry Commission on Packaging and Labelling of 1995 made the following point which is salient to other categories of waste beyond packaging:

  "One area where social cost pricing is important is pricing inputs to packaging production. In particular, inappropriate pricing of virgin resources and energy has significant implications for packaging waste management issues. Efficient levels of packaging production, reuse, recycling and disposal will only be attained if virgin and used resources are fully costed." (Industry Commission 1995)

  > *The aluminium industry is noted for the level of subsidy that electricity supply receives. While the precise benefit is reported as commercial-in-confidence, the Australia Institute have modelled and reported on government subsidies to the sector. Such subsidies are typically not available to the fragmented industries operating in the waste collection and reprocessing fields.*

  The removal of direct subsidies, it is argued, will bring improvements in the financial efficiency of the economy whilst achieving greater welfare benefits. It is reported that the inappropriate appraisal of financial values distorts markets and suppresses economic growth (Department of Environment Sport and Territories undated). The 1998 OECD report, entitled *Improving the Environment through Reducing Subsidies*, concluded that many subsidies damage the environment by encouraging over-production and the wasteful use of inputs.

4.2 Disposal pricing

As a whole, society chooses what to do with its post-consumer material. A key influencer in this decision is the relative cost of two main options:

- Disposal to landfill
- Various methods of resource recovery through collection, reprocessing, and recycling.

On the whole, the financial unit cost for disposal of waste to landfill is cheaper in Australia than the financial unit cost for resource recovery of most materials. This is fundamentally because current landfill charges do not include the full social costs of use, including allowance for loss of environmental amenity for host communities, insurance against future environmental contingencies, and remediation of sites.

Table 4-15 shows landfill disposal costs by population centre on a dollar per tonne basis for 2004, including levies where applicable, but excluding GST. This table clearly illustrates the gap between current costs and true costs as outlined previously in this report.

Table 4-15 Landfill disposal costs by population centres, 2003–04

Population Centre	2003–2004 Landfill Levy[(1)] ($/tonne)	Landfill Disposal Cost Including Levy ($/tonne)
Sydney	$19.80	$77
Melbourne	$5.00	$34
Brisbane	$0.00	$56
Perth	$3.00	$30
Adelaide	$10.09	$51
Canberra	$0.00	$50
Newcastle	$11.40	$50
Gold Coast	$0.00	$55

(1) The amount of levy varies by state. Many states (e.g. NSW, Vic WA) are in the process of increasing or considering increasing the levy.

Nevertheless, this barrier is lessening as landfill costs have risen considerably in recent years. In the Sydney metropolitan area, for example, the costs to dispose one tonne of domestic waste to landfill was $18 in 1990. The equivalent 2003–2004 cost is $77 (exclusive of GST). This is due to several reasons. One is the partial internalisation of some social and environmental externalities, such as stricter environmental regulations, increasing financial allocation for rehabilitation, and ongoing post-closure environmental management of landfill sites. In some jurisdictions, there is also the related use of landfill levies. Another reason is increasingly limited supply of suitable disposal locations close to major metropolitan cities due to competing land uses. However, these factors vary significantly between population centres; some jurisdictions, for instance, continue to have no landfill levy.

The change in putrescible waste disposal costs in the period 1990 to the present is shown in Figure 4-3 below. Also shown is what would have happened to waste disposal charges if they only increased in line with CPI (bottom lines).

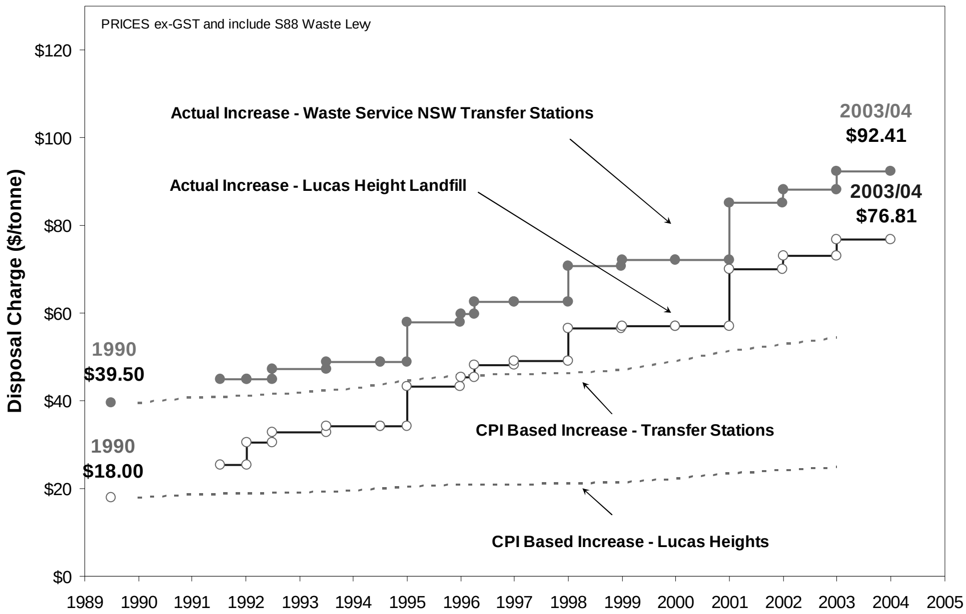


Figure 4-3 Development of landfill costs in Sydney

In relation to landfill disposal levies, these are determined and administered by State and Territory environmental agencies with some yet to introduce a levy (i.e. Queensland, Northern Territory and the ACT). The 2003–2004 current and future levels of the levy for each population centre are shown in Table 4-16 below (but it should be noted that the NSW situation has subsequently changed, e.g. a quicker timeframe).

Table 4-16 Current and future levels of the landfill levy by population centre

Population Centre	2003–2004 Landfill Levy ($/tonne)	Future Landfill Levy	
		Amount ($/tonne)	Date applicable
Sydney	$19.80	$56.70 (2)	July 2010
Melbourne	$5.00	$9	July 2007
Perth	$3.00	$6	Under consideration
Newcastle	$11.40	$25	July 2012

(1) Levies are typically raised annually in equal increments. Actual amount of future levy may be higher than indicated as some states include CPI adjustment.

(2) For Sydney. $52.50 for Extended Regulated Area.

Additionally, there is the issue of the point in the production / consumption / disposal chain at which the cost of disposal and/or resource recovery is allocated. For the most part, waste management costs are increments to rates rather than user charges related to either consumption behaviours or resource recovery behaviours. On the one hand, waste and/or resource recovery costs are not incorporated or internalised into product prices where this may be effective and efficient. On the other hand, there is generally no differentiation between waste disposal costs and resource recovery costs in most rates notices and, therefore, no signal to the consumer to incentivise resource recovery.

In sum, the comparatively lower cost of landfill disposal, and the lack of transparency in waste management and resource recovery price signals, are barriers to improved resource recovery.

4.3 Community awareness

Australians' attitudes toward waste issues are complex and constitute a barrier to improved resource recovery.

On the one hand, research paints an overall picture of people "wanting something done about waste and wanting the opportunity to do something about waste". The majority of Australians are concerned about the environment, and rank waste and/or garbage disposal in the top five or six issues of environmental concern after air pollution, freshwater pollution, ocean/sea pollution, greenhouse emissions, and destruction of habitats (ABS 1994 – 2003; NSW EPA 2000; DEC NSW 2003). A survey for Sustainability Victoria found that 98 per cent of respondents agreed that "the way we collect and dispose of waste in Victoria is an important environmental issue".

In fact, the behaviours that are most commonly performed to help the environment are related to waste minimisation. The majority of Australians (95%) recycle waste (ABS 2003). Over the last decade, kerbside recycling is consistently cited as the behaviour that is most commonly performed to help the environment.

On the other hand, it would appear to be the case that the community's concern about waste translates into only a limited range of resource recovery behaviours and practices, e.g. largely kerbside recycling and, more recently, shopping bag reuse.

These embraced behaviours tend to:

- provide a personal benefit
- be affordable
- be easily accessible.

For example, kerbside recycling is seen by the community as a tangible and accessible way of easily making a difference (Nolan-ITU 2000; Sustainability Victoria 2003; BIEC 1997).

Resource recovery and waste minimisation behaviours where the benefits are less tangible and/or the participation costs are higher are less well supported. This includes:

- participation in home composting

- participation in the resource recovery of items requiring “take-back” activity, such as mobile phones, tyres, batteries, and electronic goods.

Generally, and while the studies in this area are by no means robust, there appears to be a reasonably low willingness to pay for resource recovery.

It should also be noted that kerbside recycling of packaging and paper has been strongly supported by awareness raising and educational activity for approaching 20 years in Australia. In Sydney, Councils are estimated by Nolan-ITU to spend up to $3 per year per household on such activity. Recent efforts to promote reuseable bags for shopping have also been extensive. On the other hand, efforts to make the community aware of the waste impacts of non-packaging and non-paper items and to communicate alternative resource recovery opportunities to them have been much less developed or non-existent.

At the broader level, while environmental concern in the community remains high, it has declined steadily over the last decade (ABS 2003). This appears related to the main drivers for environmental concern to be falling away: immediacy of the environmental problem; perception of whether there is a solution at hand, and; competing concern about other issues, such as unemployment (BCA 2004).

This is also reflected in the current state of concern about waste in Australia. For example, most waste-related impacts are “out of sight and out of mind”. Personal exposure to landfills is not a common experience for many urban Australians. At the same time, easy access to kerbside recycling of packaging and paper creates a perception that the waste problem is being managed. Finally, the number of issues and media messages competing for public attention has never been greater and the “war on waste” pales in comparison to real wars.

In sum, improvement in resource recovery is confronted by the following community-related barrier:

- A lower level of awareness about and motivation to act on non-packaging and non-paper waste items
- A lower level of willingness to participate in resource recovery efforts that are not cheap, convenient, and featuring tangible benefits.

4.4 Infrastructure availability

The lack of appropriate infrastructure is another barrier to improved resource recovery in Australia. Significant infrastructure expansion would be necessary to:

- Substantially increase resource recovery levels from current household organic waste
- Substantially increase resource recovery levels from current household residual waste (through alternative waste treatment)

- Substantially increase resource recovery levels from current household bulky items waste, such as tyres, computers, mobile phones, white goods, etc.
- Increase the resource recovery levels from all non-domestic settings (e.g. the commercial and industrial sector), starting with common materials such as packaging, paper and organics.

Infrastructure requirements range from collection and transport systems, transfer and bulk up stations, sorting facilities, reprocessing facilities, and remanufacturing facilities.

There is a lack of necessary infrastructure for at least the following reasons:

- Lack of public support for resource recovery infrastructure
- The resource recovery industry's lack of certainty about planning policy
- The resource recovery industry's lack of surety of supply
- The resource recovery industry's unwillingness to bear total risk.

In the first respect, resource recovery is necessarily burdened with the stigmas associated with historic waste management. This is very difficult to overcome in terms of achieving public acceptability for resource recovery facilities in any proximity to residential areas. This is somewhat ironic given the community's genuine overall desire to address waste issues.

In the second respect, experience[4] has shown that it is often very difficult to get development approval for resource recovery infrastructure even if:

- there is limited to no community opposition
- it provides a state-of-the-art, necessary solution
- existing zoning is appropriate.

While in NSW recent planning reform appears to have brought some unity and improvement into approval processes (Stone 2005), the industry remains concerned on a national basis about possible split responsibilities regarding zoning, planning, works approvals and siting between a multitude of agencies and spheres of government.

In the third respect, as with any industry, the resource recovery industry will generally only make capital investments and provide infrastructure where there is security of supply of material and sufficient volumes of material. Where the organisation of resource recovery of some materials is via local government, there exists an effective mechanism for achieving surety of supply. Namely, industry can contract with a clear and reasonably limited number of parties for an estimable amount of supply of recyclable materials.

[4] Rethmann aborted plans to establish a much needed resource recovery facility despite initial consent of the Land and Environment Court due to persistent resistance by Botany Council.

Materials that require such supply security include paper, and in some cases, garden organics. In terms of many of the materials that require improvement in resource recovery (such as virtually all those produced in the commercial and industrial sector), there is currently no clear path to achieving such surety of supply. Namely, there are literally hundreds of thousands of businesses involved, few of whom have significant drivers to improve their own resource recovery performance.

In the fourth respect, State and Territory Governments – with the exception to date of Victoria - have not significantly supported resource recovery infrastructure development by the private sector in Australia. For its part, and considering the previously discussed factors, industry is in turn hesitant to bear 100% risk for what it argues is in part the delivery of environmental outcomes dictated by public policy, or a social service / public utility.

4.5 Policy instruments

Waste management policy is a potentially powerful tool to drive resource efficiency throughout the entire economy. Policy instruments can not only minimise the impact of waste but also operate to retain materials within the economy by recycling and remanufacture. In this way, waste policy can not only reduce the losses of primary extractive raw materials but provide macroeconomic gain by reducing the loss of value previously added to materials by prior production processes (Ayres, 2005).

Policy instruments include:

- ***Landfill levies*** – these can be set to reflect externalities or to drive a level of behaviour by ensuring that disposal as a management option is less cost competitive against resource recovery practices.

  Differential pricing based on the environmental performance of alternative management options is an effective option to encourage best practice. Where an environmental benefit is achieved (e.g. recycling), a credit or subsidy rather than levy could be provided. The justification of such a scheme rests squarely on the environmental cost benefit and as such is consistent with National Competition Policy.

- ***National resource recovery targets*** and objectives for products and materials.

  National targets for packaging materials have historically enabled the effectiveness of packaging recovery schemes to be measured and reported against.

- ***Producer Responsibility*** - this may include shared responsibility programs such as the National Packaging Covenant or producer responsibility programs requiring nominated levels of industry responsibility. Extended Producer Responsibility has been legislated for in some states.

> *There are a few examples of producer responsibility programs in Australia. These include the beverage industry, recycled oil, electronics and batteries. Initiatives taken range from manufacturer redesign considerations (electronics and beverage) to collection schemes (oil) and levy schemes (tyres). Success if often dependent on the degree of government involvement or threat of more mandatory measures.*

- ***Purchasing Policies*** - this includes offering incentives for recycled content products (RCPs) or environmentally preferable products by the public or private sectors, or the general community.

- ***Labour support schemes.*** Resource recovery activities are typically more labour intensive than production processes based on virgin resources. Activities might require dismantling of component parts, skilful repair and restoration or sorting into precise grades. Schemes which assist the supply of labour to these sectors could ensure that the recovered product was more cost competitive with the non-recovered alternative.

> *The life of computer hardware, for example, could be extended by labour support to assist small boutique industries working in hardware repair and recovery. While some firms operate profitably by repairing computers that are 3 – 5 years old, beyond this, extending the life of obsolete computers requires that they are disseminated either free of charge or for a nominal charge. After 3 - 5 years, hardware units are typically obsolete in commerce. A computer may be re-used once in a cost effective way but after that time, recovery is largely a not-for-profit exercise with dissemination to sectors of the community such as pensioners and the unemployed.*

- **Support for resource recovery infrastructure investment.**

While there are waste strategies and their targets in place in various States, the situation remains that:

- some waste streams have different targets in different constituencies
- some waste streams have no targets.

As a result, there is a lack of focus on the part of all players in respective waste/resource chains on what needs to be achieved and by whom. It virtually goes without saying that there has been no national overall waste or resource recovery target since the early 1990's.

With the exception of the businesses who are now subject to and/or participants in negotiations with jurisdictions about their "extended producer responsibilities" and those businesses that are signatories of the National Packaging Covenant, there is virtually no reason for businesses to improve their resource recovery performance. The "pro-active" drivers associated with cost reduction opportunities or brand reputation are limited. The "reactive" drivers associated with compliance with public policy are virtually non-existent. In fact, the vast majority of governmental activity has been aimed at facilitation and encouragement rather than compulsion or regulation. This may well be a strategic error given the limited commercial benefits of voluntary resource recovery activity for many businesses. By way of contrast, businesses throughout the country are subjected to specific regimes and expectations in terms of other environmental impacts, such as energy usage, water usage, and pollution.

There is limited effort to stimulate resource recovery through policy instruments that influence recyclate demand and, thereby, create greater pull in the resource recovery system. On the one hand, and in contrast to overseas jurisdictions, there are no targets, financial incentives, or mandatory requirements in terms of recycled content purchasing for public sector agencies. Public sector efforts are limited to internal facilitation, information, and reporting. On the other hand, there is virtually no policy effort and/or public sector contribution to encouraging companies and consumers to purchase recycled content products.

5 References

ACT JRG & ACT NoWaste, 2004, *Canberra Residential Waste Audit April 2004*, prepared by Aprince Consulting.

ACT NoWaste, 2000.

ACT NoWaste, 2005, *Progress towards No Waste by 2010*, viewed 4 January 2006, <http://www.nowaste.act.gov.au/strategy/statistics.html>.

Brunner.P. and Baccinni.P, 1991, *The Metabolism of the Anthroposphere. Geneva*.

Clean Up Australia, 2004, *Rubbish Report*.

Department of Environment Sport and Territories, 1996, *Environmental Economics Research Paper No 2 Subsidies to the use of Natural Resources.*

Department of Environment Sport and Territories, undated, *Commonwealth of Australia Forest Externalities – Estimating Values for Australia's Native Forests.*

Eunomia Research & Consulting, 2003, Economic Analysis of Options for Managing Biodegradable Municipal Waste, European Commission.

European Commission, 2000, *ExternE – the External Costs of Transport and Energy Systems Summary Report*.

European Parliament and the Council of the European Union, 2002, *Regulation (EC) No 2150/2002 of the European Parliament and of the Council of 25 November 2002 on waste statistics (OJ L 332, 09.12.2002, p.1), last amended by Regulation (EC) No 782/2005 (OJ L 131, 25.05.2005, p.26)*.

European Union, 2004, *6th Environmental Action Plan: Towards a thematic strategy on the sustainable use of natural resources*.

EUROSTAT, 2005, *Waste Generated and Treated in Europe*.

Golder Associates, 1999, *Report on Waste Profile Study of Victorian Landfills*, prepared for Victoria EPA.

Industry Commission on Packaging and Labelling Draft Report, 1995, page 162.

National Packaging Covenant Council, 2001, *Independent Assessment of Kerbside Recycling in Australia*, prepared by Nolan-ITU.

Nolan-ITU, 1998, *Biowaste Processing Life Cycle Assessment and Environmental Valuation* (Proposed Enclosed Biowaste Processing Facility at Lucas Heights), Waste Service NSW and the Southern Sydney Waste Board.

Nolan-ITU, 2004, *National Benefits Study of UR-3R Implementation*, prepared for Global Renewables Limited.

Nolan-ITU and Access Economics, 2002, O*rganic Waste Economic Values Analysis,* prepared for the Department of Industry and Trade, and Environment Protection Agency.

Nolan-ITU. (1998). Evaluation of the Proposed Garden Waste Ban. For the State Waste Advisory Council, 1997. Update for the Central Coast Waste Board, 1998.

NSW DEC, 2004, *Getting more from our recycling Systems – Assessment of Domestic Waste and Recycling Systems*, prepared by Nolan-ITU for NSW Jurisdictional Recycling Group and Publishers National Environment Bureau.

NSW DEC, 2005, *TBL Assessment of Garden Organics Management*, prepared by Nolan-ITU.

NSW DEC, 2004, *Waste Avoidance and Resource Recovery in NSW - A Progress Report*.

NSW EPA, 1999, *Waste Disposal Trends in NSW*.

NSW EPA, 2003, *NSW State of the Environment Report 2003*.

OECD, 2001, *Full Cost Pricing of Transport and other Systems*, France DG XVII

Pearce. D. W and Turner.K, 1990, *Economics of Natural Resources and the Environment*, Harvester Wheatsheaf.

Queensland EPA, 2004, *The State of Waste and Recycling in Queensland 2003*.

R. U.. Ayres and J.c.J.M. van den Bergh, 2005, *A theory of Economic Growth with Material / Energy Resources and Dematerialisation: Interaction of Three Growth Mechanisms,* Elsevier Journal for Ecological Economics.

R. U. Ayres, 2001, *Industrial Metabolism: Theory and Policy*.

RMIT and Nolan-ITU, 2003, *Life Cycle Assessment of Waste Management Options in Victoria*, prepared for Sustainability Victoria.

RMIT and Nolan-ITU, 2003, *Life Cycle Assessment of Waste and Resource Recovery Options (including energy from waste).*

Rodrigues, R., 2004, *Constraints on Dematerialisation and Allocation of Natural Capital along a Sustainable Economic Path*, Elsevier Journal for Ecological Economics.

SA EPA, 2002, *Consultancy report: Survey and Audit of Kerbside Waste and Recycling Practices*, prepared by Nolan-ITU and Waste Audit.

SA EPA, 2003, *State of the Environment Report for South Australia 2003*.

Stone, Y., 2005, Presentation to the NSW Waste Conference 2005.

Sustainability Victoria, 2002, *Solid Industrial Waste Plan Data Report,* prepared by Nolan-ITU.

Sustainability Victoria, 2004a, *Local Government Data Collection 2002-2003: Waste Management Services*.

Sustainability Victoria, 2004b, *Annual Survey of Victorian Recycling Industries 2002-2003*.

Sustainability Victoria, 2004c, *Towards Zero Waste: Changing the corporate & community mindset,* Sustainability Victoria Annual Report 2003-04.

Sustainability Victoria, 2005, *Waste Generation Data*, viewed 19 January 2006, <http://www.ecorecycle.sustainability.vic.gov.au/www/html/981-waste-generation-data.asp>.

UK Environment Agency, Coleman. T., 1998, *Presentation of LCA research program to International Expert Group for LCA and Waste Management,* May 1998.

USEPA, Thornloe. S.J, 1998, *Presentation of LCA research program to International Expert Group for LCA and Waste Management,* May 1998.

Various NSW and Sydney Metropolitan Regional Waste Plans and Updates, 1996 to 2000.

WA EPA (Ranka Kotur), *RRR Scheme*. Personal communication on 4 November 2004.

WA EPA, 2005, Personal communication.

WMB, Waste Management Board, 2003, *Summary Report of Waste to Landfill, Perth Metropolitan Region*.

Zero Waste SA, 2004, *Landfill Survey Zero Waste South Australia*.

Appendix 1

Material based summaries for disposal and recycling from the municipal, C&I and C&D waste streams across Australia.

Material disposed and recycled from the municipal, C&I and C&D waste streams, NSW 2002–03

Material	Municipal			C&I			C&D			Total		
	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate
	Tonnes	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*
Paper & cardboard	265,000	337,000	56%	454,000	428,000	49%	5,000	0	0%	723,000	764,000	51%
Plastics	114,000	25,000	18%	284,000	35,000	11%	13,000	0	0%	410,000	59,000	13%
Glass	81,000	126,000	61%	28,000	45,000	62%	—	—	—	109,000	171,000	61%
Ferrous	42,000	15,000	26%	85,000	500,000	85%	55,000	500,000	90%	182,000	1,015,000	85%
Garden organics	630,000	651,000	51%	85,000	192,000	69%	21,000	0	0%	736,000	842,000	53%
Food	637,000	0	0%	114,000	46,000	29%	—	—	—	751,000	46,000	6%
Timber	—	—	—	199,000	49,000	20%	117,000	83,000	41%	315,000	131,000	29%
Soil / Rubble	—	—	—	—	—	—	521,000	956,000	65%	521,000	956,000	65%
Concrete	—	—	—	—	—	—	466,000	1,451,000	76%	466,000	1,451,000	76%
Other recyclables (1)	7,000	4,000	36%	28,000	72,000	72%	32,000	319,000	91%	67,000	395,000	85%
Other waste (2)	395,000	0	0%	1,558,000	0	0%	112,000	0	0%	2,065,000	0	0%
Total	**2,170,000**	**1,156,000**	**35%**	**2,831,000**	**1,365,000**	**33%**	**1,340,000**	**3,309,000**	**71%**	**6,341,000**	**5,830,000**	**48%**

(1) Comprises aluminium and other non-ferrous metals, liquid paper board, 'mixed hardcore' C&D waste and other C&D waste.

(2) Comprises mixed and contaminated waste not suitable for recycling, including asbestos and contaminated soil.

Material disposed and recycled from the municipal, C&I and C&D waste streams, Victoria 2002–03

Material	Municipal			C&I			C&D			Total		
	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate
	Tonnes	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*
Paper & cardboard	153,000	243,000	61%	131,000	575,000	81%	8,000	0	0%	293,000	818,000	74%
Plastics (1-3)	45,000	23,000	34%	13,000	46,000	78%	3,000	0	0%	61,000	69,000	53%
Other plastic	68,000	0	0%	44,000	0	0%	3,000	0	0%	115,000	0	0%
Glass	105,000	46,000	30%	35,000	27,000	43%	0	13,000	100%	140,000	85,000	38%
Metals	110,000	169,000	61%	73,000	735,000	91%	28,000	68,000	71%	211,000	971,000	82%
Food waste	589,000	0	0%	133,000	22,000	14%	—	—	—	723,000	22,000	3%
Garden organics	275,000	200,000	42%	86,000	15,000	15%	36,000	3,000	7%	397,000	217,000	35%
Wood / Timber	99,000	16,000	14%	244,000	140,000	36%	114,000	14,000	11%	457,000	169,000	27%
Other organics	49,000	3,000	5%	29,000	137,000	83%	15,000	2,000	9%	93,000	141,000	60%
Clean excavated material	18,000	unknown	unknown	35,000	unknown	unknown	890,000	unknown	unknown	943,000	unknown	unknown
Concrete, bricks & asphalt	18,000	42,000	70.3%	81,000	21,000	21%	443,000	1,789,000	80%	542,000	1,852,000	77%
Textiles	0	4,000	100.0%	46,000	23,000	33%	0	57,000	100%	46,000	84,000	64%
Other	18,000	0	0.0%	51,000	0	0%	90,000	0	0%	158,000	0	0%
Total	**1,547,000**	**744,000**	**32.5%**	**1,003,000**	**1,740,000**	**63%**	**1,630,000**	**1,945,000**	**54%**	**4,180,000**	**4,429,000**	**51%**

Material disposed and recycled from the municipal, C&I and C&D waste streams, Queensland 2002–03

Material	Municipal			C&I			C&D			Total		
	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate
	Tonnes	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*
Paper & cardboard	636,000	98,000	13%	unknown	unknown	unknown	unknown	unknown	unknown	unknown	254,677	unknown
Plastic	21,000	9,000	30%	unknown	unknown	unknown	unknown	unknown	unknown	unknown	12,080	unknown
Glass	83,000	45,000	35%	unknown	unknown	unknown	unknown	unknown	unknown	unknown	45,239	unknown
Ferrous	33,000	4,000	12%	unknown	unknown	unknown	unknown	unknown	unknown	unknown	6,303	unknown
Non-ferrous (incl. aluminium)	7,000	2,000	18%	unknown	unknown	unknown	unknown	unknown	unknown	unknown	1,655	unknown
Organics	159,000	286,000	64%	unknown	unknown	unknown	unknown	unknown	unknown	159,000	391,000	unknown
Other	358,000	0	0%	unknown	unknown	unknown	unknown	unknown	unknown	unknown	8,068	unknown
Total	**1,297,000**	**445,000**	**26%**	**747,000**	**212,000**	**22%**	**678,000**	**488,000**	**42%**	**2,722,000**	**1,251,000(2)**	**31%**

(1) The total recycling figure for Queensland includes 105,000 tonnes of organics which is recycled by the private sector and the waste stream split is unknown.

Material disposed and recycled from the municipal, C&I and C&D waste streams, WA 2002–03

Material	Municipal			C&I			C&D			Total		
	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate
	Tonnes	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*
Paper & cardboard	105,000	42,000	38.5%	unknown	144,000	unknown	unknown	0	unknown	unknown	186,000	unknown
Plastic	10,000	4,000	28.8%	unknown	3,000	unknown	unknown	0	unknown	unknown	7,000	unknown
Glass	43,000	16,000	23.5%	unknown	2,000	unknown	unknown	unknown	unknown	unknown	18,000	unknown
Metals	16,000	22,000	15.6%	unknown	174,000	unknown	unknown	82,000	unknown	unknown	278,000	unknown
Organics	353,000	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
Concrete, sand, brick and rubble	unknown	6,000	unknown	unknown	0	unknown	unknown	327,000	unknown	unknown	334,000	unknown
Rubber	unknown	0	unknown	unknown	2,000	unknown	unknown	0	unknown	unknown	2,000	unknown
Textiles	unknown	1,000	unknown	unknown	0	unknown	unknown	0	unknown	unknown	1,000	unknown
Other waste [(1)]	213,000	0	0.0%	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
Total [(2)]	**741,000**	**92,000**	**11%**	**420,000**	**324,000**	**44%**	**1,535,000**	**410,000**	**21%**	**2,696,000**	**826,000**	**23%**

(1) Comprises non-recyclable plastics and glass, ceramics, dirt & dust, wood and rubber, hazardous waste.

(2) The total disposal figure for WA is for metropolitan Perth. Recycling figures are not yet publicly available for WA. Recycling figures are not yet publicly available for WA, but have been provided by the Department of Environment (WA) for inclusion in this report.

Material disposed and recycled from the municipal, C&I and C&D waste streams, SA 2002–03

Material	Municipal			C&I			C&D			Total		
	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate
	Tonnes	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*
Paper & cardboard	55,000	50,000	48%	17,000	86,000	83%	800	0	0%	73,000	136,000	65%
Plastics	62,000	11,000	54%	3,000	4,000	55%	600	0	0%	73,000	15,000	84%
Steel		15,000		3,000	243,000	99%	2,000	46,000	96%		304,000	
Non-ferrous metals		6,000		0	21,000	99%	0	5,000	100%		32,000	
Glass		41,000		2,000	5,000	68%	300	0	0%		46,000	
Concrete	—	—	—	2,000	0	0%	11,000	875,000	99%	13,000	875,000	99%
Brick & tile / rubble & soil	—	—	—	28,000	0	0%	653,000	327,000	33%	681,000	327,000	32%
Asphalt	—	—	—	—	—	—	4,000	100,000	96%	4,000	100,000	96%
Timber	0	6,000	0%	13,000	23,000	63%	6,000	87,000	93%	20,000	116,000	85%
Garden organics	80,000	102,000	56%	9,000	13,000	59%	3,000	13,000	80%	92,000	127,000	58%
Food organics	95,000	0	0%	42,000	74,000	64%	700	0	0%	137,000	74,000 (2)	35%
Textiles	0	3,000	100%	5,000	1,000	13%	300	0	0%	6,000	4,000	42%
Rubber	0	100	100%	8,000	0	0%	100	0	0%	8,000	100	1%
Other waste (2)	73,000	0	0%	76,000	0	0%	21,000	0	0%	170,000	0	0%
Total	**365,000**	**235,000**	**39%**	**208,000**	**469,000**	**69%**	**704,000**	**1,452,000**	**67%**	**1,277,000**	**2,156,000**	**63%**

(1) The total recycling figure for SA includes meat waste, a prescribed industrial waste.

(2) Includes items such as garbage bags, flock, plasterboard, asbestos, sawdust, plastic bags & film, asbestos, other C&I and C&D waste, other hazardous waste, and treatment plant residue.

Material disposed and recycled from the municipal, C&I and C&D waste streams, ACT 2002–03

Material	Municipal			C&I			C&D			Total		
	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate
	Tonnes	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*
Paper & cardboard	15,000	19,000	56.3%	50,000	unknown	unknown	0	unknown	unknown	65,000	45,000	41%
Plastics	1,000	1,000	50.2%	3,000	unknown	unknown	0	unknown	unknown	4,000	21,000	54%
Glass	5,000	8,000	61.9%	3,000	unknown	unknown	0	unknown	unknown	8,000		
Ferrous	2,000	1,000	22.7%	2,000	unknown	unknown	0	unknown	unknown	5,000		
Aluminium	200	200	45.5%	1,000	unknown	unknown	0	unknown	unknown	1,000		
Organics	35,000	0	0.0%	27,000	unknown	unknown	3,000	unknown	unknown	65,000	163,000	71%
Textile / Carpets/ Rags	—	—	—	2,000	unknown	unknown	0	unknown	unknown	2,000	4,000	65%
Leather / Rubber / Tyres	—	—	—	1,000	unknown	unknown	0	unknown	unknown	1,000	unknown	unknown
Concrete	—	—	—	0	unknown	unknown	6,000	unknown	unknown	6,000	unknown	unknown
Bricks / Tiles	—	—	—	0	unknown	unknown	2,000	unknown	unknown	3,000	unknown	unknown
Soil / Rubble / Inert	—	—	—	0	unknown	unknown	13,000	unknown	unknown	13,000	unknown	unknown
Other waste [(1)]	24,000	0	0.0%	8,000	unknown	unknown	3,000	unknown	unknown	35,000	unknown	unknown
Total	**82,000**	**29,000**	**26.0%**	**98,000**	**52,000**	**35%**	**27,000**	**223,000**	**89%**	**207,000**	**467,000[(2)]**	**69%**

[(1)] Includes materials such as asphalt, concrete, soil & inert, ceramics, soft plastics, chemicals, nappies, plasterboard, fibreglass, asbestos, ash, contaminated soil, medical and hazardous waste.

[(2)] The total recycling figures for the ACT includes cooking oil and fat, motor oil, salvage &reuse, and paint, whereby data was provided in aggregate.

Material disposed and recycled from the municipal, C&I and C&D waste streams, Tasmania 2002–03

Material	Municipal			C&I			C&D			Total		
	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate
	Tonnes	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*
Paper & cardboard	unknown	8,000	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
Plastic	unknown	1,000	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
Glass	unknown	8,000	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
Ferrous	unknown	1,000	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
Aluminium	unknown	400	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
Total	**unknown**	**19,000**	**unknown**	**unknown**	**unknown**	**unknown**	**unknown**	**unknown**	**unknown**	**unknown**	**unknown**	**unknown**

Material disposed and recycled from the municipal, C&I and C&D waste streams, NT 2002–03

Material	Municipal			C&I			C&D			Total		
	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate	Disposal	Recycling	Diversion Rate
	Tonnes	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*	*Tonnes*	*Tonnes*	*%*
Paper & cardboard	unknown	5,000	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
Plastic	unknown	300	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
Glass	unknown	1,000	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
Ferrous	unknown	100	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
Aluminium	unknown	100	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
Total	**unknown**	**7,000**	**unknown**	**unknown**	**unknown**	**unknown**	**unknown**	**unknown**	**unknown**	**unknown**	**unknown**	**unknown**

Appendix 2

Environmental Assessment

Environmental Assessment

The valuation of externalities associated with waste management options presented in the table are sourced from extensive cost benefit analysis in waste management. The assessments have aimed to define and value the environmental externalities (or non-financial costs and benefits) associated with various management strategies for municipal solid waste.

The environmental assessment is based on Life Cycle Assessment and environmental economic valuation using primarily damage cost values. The assessment method proceeds in a systematic way to quantify material and energy inputs and outputs to the waste management system; and then values these flows using established economic values as depicted below. The four steps in the assessment approach are summarised in Figure A-4.

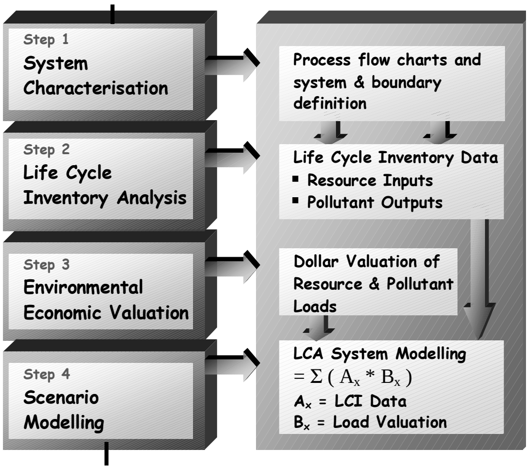


Figure A-4 Assessment Methodology

Step 1: System Characterisation

Analysis of the environmental impact of any waste management system requires that the entire life cycle of the system is studied from cradle to grave. All inputs to, and outputs from, the system need to be recorded from the point of waste collection, through the various processing steps and on to the management of residuals and products. This included detailed consideration of any avoided systems, notably:

- Avoided landfill
- Avoided energy production
- Avoided commodity material stages associated with materials recovery and recycling.

Step 2: Life Cycle Inventory Data

Life Cycle Inventory Data on the resource inputs and pollutant outputs to the system were developed or referenced from existing published studies.

The range of resource inputs and pollutant outputs was extensive and exceeded 15 raw material inputs, greenhouse gases and more than 100 substances emitted to air and water that spanned general and toxic pollutants including heavy metals and chlorinated and aromatic hydrocarbons, including dioxins and furans.

Step 3: Environmental Economic Valuation

The Australian-based, environmental economic valuation method (Nolan-ITU 2001) was applied in order to derive a monetary cost benefit assessment. The method uses environmental economic values that have been either directly sourced, or derived from published government sources within Australia.

Where the values are "derived", scientific equivalence factors are used to relate a known base pollutant to the derived value in accordance with Life Cycle Impact Assessment characterisation approaches (Heijungs 2001).

The impact categories assessed are:

- Greenhouse Gases
- Air Emissions
- Water Emissions
- Resource Conservation (with 'Oil & Gas' as separate (sub-category)
- Solid Waste (reflecting non-chemical impacts of landfilling.

Short Description of Impact Categories

The derivation of the original environmental economic values for each impact category (Nolan-ITU 2001) was a detailed assignment. A summary of the approach is described below. For a more complete understanding of the approach, please refer to the *Independent Assessment of Kerbside Recycling in Australia, National Packaging Covenant Council (2001)*.

Water and Air Pollutant Valuation

Pollutant emissions from the inventory are classified as Water Pollution or Air Pollution if they have the potential to affect human health or the environment. Environmental economic values from published government sources are used where possible to assign economic values to pollutants on a per tonne basis. If values are not available from government sources, scientific equivalence factors are used to scale the economic values for known pollutants in order to derive the unknown pollutant values.

Equivalence factors are derived from local regulations including the NSW EPA (1997) Proposed Clean Air (Plant and Equipment) Regulation 1997 and the NSW EPA (1998) Load Based Licensing Scheme and published international LCIA references including the Themes Approach of the Centre of Environmental Science (CML) Leiden University, Netherlands.

Base pollutant values for air include: (AUS$/kg) are SO2: $0.44, NOx: $3.82, Fine Particulates (PM10): $18.50, CO: $0.025.

Base pollutant values for water include: (AUS$/kg) Lead $226. (Nolan-ITU & SKM Economics 2001)

Greenhouse Gases

Greenhouse Gases or global warming pollutants are common to all inventory data sets including the UR-3R Facility, landfill and energy inventories.

The Climate model as developed by the Intergovernmental Panel on Climate Change (IPCC) has been used to provide equivalence factors to assess pollutants. These are expressed in terms of carbon dioxide equivalence and an economic value of $20.00 per tonne of carbon dioxide is used. A limited range of greenhouse gases has been considered. (Nolan-ITU & SKM Economics 2001)

Resource Conservation

The resources modelled are the most significant resources by weight in the inventories used: They include a range of mineral, forest and soil and water resources.

Resource values have been referenced from published Australian valuation studies or estimated based on the application of international scientific ranking systems to Australian valuation data.

The final resource value cost of coal is $47.50 per tonne. This results in subsequent values (AUS $/t) of: Bauxite: $111.55, Coal: $47.51 Crude oil: $34.84 iron (ore): $80.56 limestone $91.52 and natural gas $34.84 and sand $10.37. (Nolan-ITU & SKM Economics 2001)

Solid Waste

Solid Waste is assessed in order to include the non-chemical environmental and social impacts of landfills. These are predominantly established by the EPA NSW for land value loss and loss of amenity (NSW EPA 1997).

Step 4: System Modelling

Once data sets are established, waste systems are modelled along with considerable data on various collection and management systems for Municipal Solid Waste. The inventory data is aggregated into models according to flow charts for each system and inventory results are assessed based on the impact valuation data.

Appendix 3

The Landfill System

The landfill system

Solid waste landfills are dynamic systems and the pollutant loads carried by landfill gas and leachate vary considerably over time and in accordance with a range of local variables such as landfill design and management, waste composition and local hydrology. In this context, LCA inventory data for the landfilling of MSW attempts to quantify the total pollutant load to air and water over the life of landfill. The landfill LCA data treats the landfill process as it does any waste treatment process, with the emissions to air and water recorded and assessed for their environmental impact, and credits assigned for electricity generation.

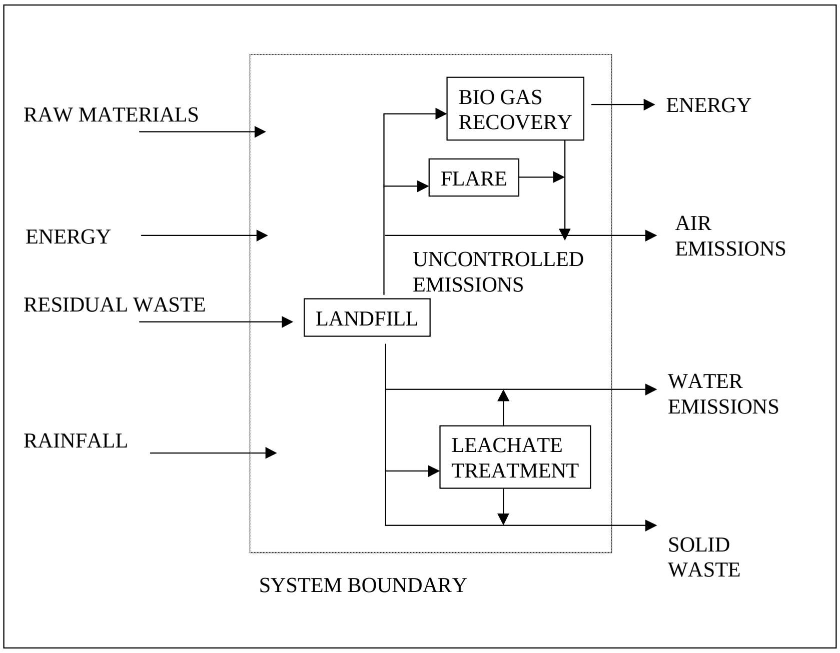


Figure A-5 Landfill system

Best practice landfill for Australian conditions is assumed. This is a conservative assumption as, in practice, not all landfills currently serving the population centres modelled achieve the assumed best practice standard. In modelling the landfill system, average data from the landfill life is allocated to a unit of waste, in this case one tonne of MSW landfilled. A 30 year time frame has been selected as this time period covers the "active" phase of the landfill, when most of the decomposition and chemicophysical changes occur. The appropriateness of this time period varies for different pollutant loads. While some pollutants are predominantly active within the first three years of the landfill only (Moore 1992), others are released over very long time periods. Results from geochemical landfill modelling (Hellweg 2000) suggest that heavy metals are released over a very long time period, ranging from a few thousand years to more than 100,000 yrs.

In theory, only the infinite time frame is compatible with the LCA framework, since all emissions should be included in an LCA (Finnveden 1999). However, a 30 year time frame was selected for this study for two reasons:

- Data is available for modelling
- A short time period selected for landfill is a conservative estimate when comparing with an alternative technology.

Derivation and source of data

The calculation of LCA data requires that concentration based data be converted to load based data per tonne of waste landfilled. Recognising that landfill data is dependant on many factors, concentration peaks and lows over an assumed active life of 30 years are considered, the arithmetic mean is calculated and then applied to the volume of gas or leachate as calculated for Australian Capital Cities. A similar methodological approach has been used previously for LCA of landfill as the basis of policy advice to the European Union and the UK Environment Agency (COWI 2000; Eunomia 2002; NSCA 2002).

An extensive review of data was conducted on landfill leachate and gas emissions (Qasim, S.R. and Chiang,W. 1994; Christensen et al. 1994; Ehrig 1989; Carra and Cossu 1990; COWI 2000; White et al. 1995; Neilson, P. 2001; National Society for Clean Air and Environmental Protection (UK) 2002; SimaPro LCA Software 2004). Local data was also sought from the University of New South Wales and the NSW Waste Recycling and Processing Corporation. The modelling of the base line landfill scenario accounts for carbon sequestration in the landfill from a range of materials in the waste/residual streams being disposed.

Landfill Leachate

Leachate generation (included contaminated run-off) is calculated to be 187.6 l/tonne over 30 years. This is based on weighted average rainfall data for Australian capital cities.

Prior to discharge to sewer, it is assumed that the following landfill leachate treatment steps are taken:

- leachate equalisation
- metals precipitation
- organic load reduction
- denitrification
- clarification and decanting.

Leachate equalisation involves the mixing of leachate in a holding tank to prevent shock loading of the biological system through the introduction of “fresh” leachate which may contain high concentrations of pesticides or other chemicals contained in newly deposited waste.

Metals precipitation is achieved through lowering the pH of leachate by dosing leachate with lime. The precipitate is settled and circulated back to landfill.

Organic load reduction is achieved using an activated sludge process or using a sequencing batch reactor. These are both biological processes which rely on micro-organisms to consume the organic matter contained in leachate. After the organic load has been reduced, the treated leachate is allowed to settle thereby clarifying the liquid. The clear liquid is then decanted to sewer.

Landfill Gas

After detailed analysis of the available landfill data, it was decided to use a mix of both material specific and generic process data. Material specific emissions are calculated based on the material composition of waste in landfill and generic data is process and technology specific. After comparison of the performance of data sets in the modelling of scenarios and the accuracy of data, it was agreed that material specific data would be used for common pollutants, including the Greenhouse Gases of CO_2, CH_4 and N_2O, and generic data would be used for trace contaminants including chlorinated and aromatic hydrocarbons and heavy metals.

Information relating to landfill management practices in national capital cites across Australia was applied to determine the extent of fugitive emissions, and emissions post flaring or engine combustion. Both data sets assume best practice landfill is adopted and that landfill gas capture is in place in 80% of landfills and that 20% operate without landfill gas collection facilities. Where collection is in place, 55% of gas is effectively collected for combustion. Of this 55%, 75% results in electricity production and the remaining 25% is flared.

Generic Process Data

Concentration based data was converted to load based emissions using conventional landfill engineering methods. Landfill gas generation is assumed to be 250 Nm3/t.

Material specific data

Material specific emission data relate to the likely generation of gases from materials. These are assumed to be not dependant on local variables and existing data is used (Sustainability Victoria 2001).

The issue of double counting was assessed for trace contaminants within the material specific data. In the final adjusted model used here, the ‘overlap’ between the generic and the material specific data was less than 1%. This was considered to be not significant enough, with respect to the impact on the final results, to warrant further work.

Greenhouse gas emissions

Conservative estimates of landfill gas production are assumed in order to cater for likely landfill management improvements over the coming 5 years. Gas capture and treatment assumptions are described above. Methane oxidation at the landfill surface and subsurface is assumed to be 10% (AGO 2004).

Greenhouse Gas emissions are highly sensitive to effective gas capture rates, and to the inclusion or exclusion of carbon sequestration benefits (which have been included in this study). Should landfill management practices not advance as expected, the avoided greenhouse gas impact associated with landfill would increase.