# 18 The role of interconnectors

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| Key points |
| * Interconnectors can be described in different ways. * Physically, they are a collection of transmission lines that join the regions of the National Electricity Market (NEM). * Functionally, they are a notional concept of the capacity to transfer energy between regions in the NEM. As the Australian Energy Market Operator has pointed out, they exist as mathematical representations within the dispatch engine of the capacity to transfer energy from one regional reference node to another (subject to network constraints and generator dispatch patterns). * Interconnectors are an essential prerequisite for integrating the six, historically state-based, electricity markets into a single NEM. * By allowing inter-regional trade in electricity, interconnectors potentially increase competition in generation, improve the financial markets that address risk for parties in the NEM, and promote greater security of supply. * Therefore, problems with the NEM regulatory arrangements can affect interconnectors, with far-reaching consequences. * While the capacity of any given interconnector sets an upper limit on the amount of power that it can transfer between two regions, other factors — such as the capacity of, and congestion on, state‑based intra-regional transmission lines, as well as the regulation of the NEM — further limits how much power flows in practice. * It is the latter degree of actual *‘interconnection’* that is policy relevant. * Some have claimed that interconnectors are congested, limiting their potential to enhance the efficiency of the NEM. * However, investment in interconnectors and associated parts of the network involves significant costs, so that some level of congestion is ‘efficient’. * Evidence suggests that, given the existing network and the profile of demand, the current *physical capacity* for interconnection is appropriate. * Underutilisation, especially in South Australia, and some instances of significant price differentials between regions warrant further investigation. |
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The terms of reference for this inquiry ask the Commission to ‘examine whether the regulatory regime, with respect to the delivery of interconnector investment in the NEM [National Electricity Market], is delivering economically efficient outcomes’. Interconnectors can provide several benefits arising from the ability to trade power between regions. As with other transmission lines, they are expensive to build. Nonetheless, in contrast to broader concerns of excessive distribution network investment, there have been concerns about *under-*investment in interconnectors.

This chapter explores the potential benefits of interconnectors in the NEM, and the extent to which those benefits are being realised in practice.

## 18.1 Background and perceived problems

Until recently, electricity markets in Australia were characterised by vertically‑integrated government-owned businesses in each state and territory. Over time, the markets in eastern Australia were linked to form the NEM. The NEM was created as a wholesale market for electricity in the mainland eastern jurisdictions in 1998, with Tasmania joining in 2005 with the completion of Basslink (AEMO 2010f). The interconnectors in the NEM facilitate the trade between the regions (effectively, the states), by allowing power to flow from lower-priced to higher-priced regions. Trade can only occur up to the capacity of the interconnector, after which local generation must meet demand in the higher-priced region. (Also, complications in market design, such as disorderly bidding by generators, discussed in chapter 19 can change the level and direction of flow.)

There are six interconnectors between the jurisdictions in the NEM (figure 18.1). Of these, three interconnectors (Basslink, Murraylink and Directlink) began as ‘merchant’ interconnectors, a topic discussed further in chapter 20.

Figure 18.1 Interconnectors in the National Electricity Market

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| Figure 18.1 Interconnectors in the National Electricity Market. This figure shows the general geographical location of interconnectors along the east coast of Australia. |

*Source*:AER (2009a, p. 54).

### Interconnectors, interconnection and transmission

It is common to refer to interconnectors as just single transmission wires spanning regions, and this is how they are depicted in maps of the NEM (figures 18.1 and 18.2). However, referring to such ‘notional’ interconnectors is an abstraction from how interconnectors work. In fact, an interconnector can be composed of several transmission lines — of varying capacity and location — linking generation and load centres (figure 18.3).

Figure 18.2 Dispatch model representation of a notional interconnectora

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| Figure 18.2 Dispatch model representation of a notional interconnector. The popular way of thinking about an interconnector is like a distinct line between two regions or interconnector regional reference nodes. |

a ‘G’ represents generators, ‘RRN’ represents the regional reference node.

*Source*: AEMO (sub. 32).

Figure 18.3 Physical interconnection between regionsa

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| Figure 18.3 Physical interconnection between regions. This figure shows how generators, regional reference nodes and demand centres are connected. Unlike the earlier graph this shows how interconnectors are physically linked. They are like a set of lines joining different networks, like multiple strands in a spider’s web. |

a ‘G’ represents generators, ‘RRN’ represents the regional reference node and ‘L’ represents load (demand centres).

*Source*: AEMO (sub. 32).

The complexity of physical electricity networks has important policy implications. When electricity networks are linked, the capacity of one line can be heavily influenced by the capacity of lines connected to it. In effect, the maximum amount of power an interconnector can transport is irrelevant if the capacity of the lines ‘behind’ the interconnector at any given time is lower. For example, if an interconnector has a capacity of 200 MW, but constraints within the regions mean that only 100 MW can reach the interconnector, then the binding factor that determines the amount of power that can be traded is the 100 MW constraint.

Further, the operation of Kirchhoff’s law[[1]](#footnote-2) in an alternating current (AC) network (like the NEM) means that a constraint on any given line will likely have some impact on a number of other lines (not just a directly connected line), particularly in areas where the network is meshed (rather than radial).[[2]](#footnote-3)

Accordingly, while the ‘capacity’ of individual interconnectors can generally be identified (table 18.1), these figures refer to the capacity of the interconnectors themselves,[[3]](#footnote-4) ignoring any constraints behind the interconnectors.[[4]](#footnote-5) In the day-to-day operation of the system, built capacity, congestion and faults on other lines, the location and behaviour of generators, and the weather can limit the degree of *interconnection* (that is the amount of power that can be transferred between regions) to below the listed levels. As the Australian Energy Market Commission (AEMC) noted in its Transmission Frameworks Review first interim report, this degree of network linkage highlights:

… the difficulty of considering intra-regional investments in isolation, since a very large proportion of all transmission investment with a mitigating impact on network constraints will have some inter-regional effect. This is illustrated by recent analysis performed for the [AEMC], which found that approximately two-thirds of all constraint equations contain an inter-regional term. (AEMC 2011f, p. 136)

Table 18.1 Interconnector capacity in the National Electricity Market

MW

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| Interconnector | Direction | Technology | Capacity | Peak observed flowsb |
| QNI | (Qld to NSW) | AC | 1078 | 1060 |
|  | (NSW to Qld) | AC | 700 | 20 |
| Directlink |  | DC | 200 | 207 |
| Vic-NSW | (Vic to NSW) | AC | undefined a | 1575 |
|  | (NSW to Vic) | AC | undefined a | 489 |
| Basslink | (Tas to Vic) | DC | 600 | 594 |
|  | (Vic to Tas) | DC | 480 | 416 |
| Heywood | (both) | AC | 460 | 460 |
| Murraylink |  | DC | 220 | 213 |

a As noted in the text, interconnectors do not have capacities as such. Instead their flows are bound by a number of constraints in the NEM dispatch engine that vary with conditions applicable at the time. The values listed above are close to the highest flows achievable in ideal network and dispatch conditions, although constraints at lower flows are common. The New South Wales to Victoria (north and south) constraints are particularly difficult to estimate. Some sources (incorrectly) apply a value for this interconnector of 1500 MW (north) and 1300 MW (south), but this value is derived solely from the number of units sold in the Settlement Residue Auction, rather than reflecting the physical aspects of interconnections (AEMO pers. comm., 2 August 2012). b These figures reflect flows (in five minute dispatch intervals) in the week beginning 30 January 2011, when temperatures exceed 40ºC in Sydney and Adelaide, and 39ºC in Melbourne. Such conditions are typically associated with peak levels of power demand. The observed flows also reflect relativities of demand as they are likely to be higher into the ‘importing’ states, such as South Australia and New South Wales.

*Sources*: AEMO (2011d, 2012f and pers. comm., 3 August 2012); Powerlink and Transgrid (2012).

A particular example of this is the Victoria–New South Wales notional interconnector, where the capacity of the ‘wires across the border’ is rarely the limiting factor. The limit is instead set by network constraints within Victoria and New South Wales, particularly around Yass (AEMO 2012f, p. 6), as well as the dispatch (or loss) of large generation units on either side of the border. Given that these other factors regularly determine flows between Victoria and New South Wales, it is difficult to ascribe a single capacity limit to the ‘interconnector’ itself. Although AEMO’s settlement residue auction process has nominated 1500 MW as the ‘northerly’ limit for the interconnector, this is purely for financial and not physical reasons.[[5]](#footnote-6) Nonetheless, the figures in table 18.1 still provide useful predictors of observed flows. For example, during the week of 30 January 2011, when temperatures in Sydney were over 40ºC, the flow on the interconnector was recorded as approaching, and in two instances, marginally exceeding, 1500 MW (AEMO 2011d, pp. 4‑5).

The degree of linkage between interconnectors and intra-regional transmission lines has important policy implications. As the Australian Energy Market Operator (AEMO) pointed out, focusing on only the ‘cross-border’ wires would not allow a full consideration of the relevant policy matters for interconnectors:

NEM commentary suffers a widespread misconception that interconnectors in fact are discrete assets joining two transmission network service companies, distinct from the meshed networks within each transmission company. This misconception can lead to a belief that national planning need be directed to these ‘interconnector assets’ alone, allowing local experts to work within their own territories with only marginal interaction with a national plan. However, … the limits to flow between regions have little to do with assets located near the border, nor even in the main pathways between load centres. (sub. DR100, p. 10)

Several other participants — including Grid Australia (sub. 22, p. 19), and the AEMC (sub. 16, p. 8) — agreed, and also noted the inseparability of intra- and inter‑regional transmission capacity, investment and planning. In policy terms, any concerns about the adequacy of investment in interconnectors must also take account of the adequacy of the transmission network as a whole.

In this context, the key issue is, thus, the overall scope to achieve economically valuable trading of power between regions, rather than the physical capacity of individual interconnectors. As well as its direct effects on regional electricity prices, the amount of power that can be transferred between regions can enhance:

* allocative efficiency — as consumption decisions respond to price levels
* productive efficiency — interconnection can allow demand centres to access the cheapest sources of generation
* dynamic efficiency — a well interconnected NEM will allow optimisation of investment in generation and transmission over time across the NEM, rather than within individual regions
* security of supply — for example, presence of the Basslink interconnector assisted in avoiding costly blackouts in Victoria during the June 2012 earthquake by providing additional power to Victoria following the unexpected loss of nearly 2000 MW of generation (AEMO 2013e), and provided Tasmania with supply security from Victorian generation when drought conditions limited hydro generation in Tasmania. As discussed in chapters 14 to 16, unreliable supply can be highly costly.

The inseparability of interconnectors from transmission within regions in turn means the current regulatory regime applying to intra-regional transmission is critical to efficient outcomes in regard to interconnectors. Similarly, the location and bidding behaviour of generators can affect the use of interconnectors, raising another set of policy issues. As the AEMC noted:

Due to the complex nature of the transmission system, the AEMC is of the view that it would be insufficient to consider what improvements could be made to the regulatory arrangements for interconnectors in isolation. The regulatory arrangements for all elements of the transmission system within the NEM should be considered in a holistic manner. (sub. 16, p. 7)

Indeed, focusing solely on the interconnectors and ignoring other fundamental policy issues, would produce inferior and potentially even adverse outcomes for the network, electricity consumers, and the community as a whole. Hence, in coming to a view on whether additional investment in interconnectors is a priority, or even required, it is important to be clear about the problem that such investment is intended to resolve.

It is in this policy context that the Commission has considered concerns relating to interconnection in the NEM.

### Concerns about interconnection in the National Electricity Market

For some time, some stakeholders have raised concerns about potential under-investment in interconnectors in the NEM. As part of his 2008 review, Garnaut suggested that, in future, interconnectors would need to allow the national integration of generators that locate in jurisdictions that have favourable low-carbon energy sources (such as areas of high, constant wind):

Without a network of interconnectors with enough capacity to cope with the potentially large shifts in interstate flows of electricity over time, much of the generation capacity must remain within a region, even if there are more economic sources elsewhere. …. Interconnector constraints will be reflected in unnecessarily high, and more regionally differentiated and volatile, energy and emissions permit prices. (Garnaut 2008, pp. 446‑7)

In the 2011 update to his review, Garnaut reiterated his concern about strong biases against interstate flows (2011b, p. 30). Previous reviews have also identified issues with interconnection (for example, Parer et al. 2002, p. 128). The International Energy Agency also identified ‘de-coupling of prices’ in adjoining states as an indicator of an emerging problem, and highlighted the importance of considering both intra- and inter-regional constraints (IEA 2005, p. 117).

Others have also identified existing regulatory and planning frameworks as inimical to adequate long-run interconnection (such as the South Australian Department of Transport, Energy and Infrastructure; and International Power in their comments to the current AEMC Transmission Frameworks Review).

But not all agree. Grid Australia noted that there are several measures ‘designed to ensure that projects with net market benefits will be identified, evaluated and constructed … [and] highlighted that all interconnectors are currently undergoing some form of assessment’ (AEMC 2011f, p. 41).

In 2007, the Energy Reform Implementation Group observed that the level of interconnection had ‘increased significantly between the state grids over the past five years’ ((ERIG 2007, p. 168), and came to the view that, overall:

… the current level of transmission and interconnection investment is reasonably appropriate for the installed generation capacity and peak demand. However, failure to ensure efficient investment in generation and transmission on a system wide basis into the future puts at risk the efficiency gains achieved as a result of previous energy market reforms. (p. 145)

In its 2008 Congestion Management Review, the AEMC concluded that congestion in the NEM was ‘not a major problem’ (apart from the then Snowy region), noting that it was ‘unpredictable’ and typically only caused mispricing for short periods before additional transmission or generation investment resolved the issue (AEMC 2008b, p. 13). However, the AEMC went on to note that in relation to interconnectors there had been:

… an increase in the total hours of binding constraints on interconnectors since NEM start. Hours rose steeply from 2139 hours in 1998/99 to 9925 hours in 2000/01. This was followed by a sharp fall to 2398 hours in 2001/02, which was caused by a reduction in outages hours binding on the Queensland-to-NSW interconnector (QNI) of 6400 hours. Since then there has been a steady rise from 6781 hours in 2002/03 to 12 849 hours in 2006/07 (or 8242 hours excluding Tasmania). (AEMC 2008b, p. 72)

The debate has not moved on much — in this inquiry, participants put forward similarly divergent views about the adequacy of current interconnection and the ability of the regulatory framework to deliver efficient levels of interconnection into the future. For example, participants submitted that:

* the currently regulatory and planning framework could only deliver ‘reliability-driven region-centric’ investment (AER, sub. 13), and not a truly ‘national grid’ (AEMO, sub. 32)
* there is a need for greater coordination in investment planning to facilitate the role of interconnectors in transporting low-emissions energy between jurisdictions in the future (Clean Energy Council, sub. 31)
* there was a low level of recent investment in interconnectors, in contrast to intra‑regional transmission lines (Major Energy Users, sub. 11). The Major Energy users also drew attention to what it saw as a ‘considerable but unnecessary transfer of wealth from consumers to generators’ (p. 12) facilitated by interregional separation (that is, when the interconnectors are unable to transport power from another region). Visy (sub. DR98) raised similar concerns.
* there was little need for greater interconnector capacity, but the issue lies with their use, as influenced by the use of market power, market design features and inadequate demand-side provision, among other things (Energy Users Association of Australia, sub. 24)
* AEMO further commented that the size of the problem caused by ‘disorderly bidding’ (chapter 19) warranted a ‘generalist solution’, and that:

Although the problem emerges in new locations of the NEM from year to year, it does not diminish. Most recently, otherwise minor events of congestion in the central Queensland region has frequently triggered widespread disorderly bidding across Queensland, severely impacting interconnector performance and producing negative residues. This is despite subdued Queensland demand which would be expected to reduce the prevalence. (sub. DR100, p. 11)

Others did not feel there was substantial evidence of any issues with interconnectors, and argued that:

* where interconnector investment is efficient, it is occurring in a ‘timely manner’, and that a lack of new projects may simply indicate that the framework is ensuring only efficient ones are built (Grid Australia, sub. 22)
* the absence of significant, sustained price separations between regions provided an indicator of sufficient inter-regional investment, but there could nonetheless be scope for enhancing transmission planning in the NEM (AEMC, sub. 16)

The views presented by generators also differed (box 18.1).

As the subsequent sections make clear, assessing the validity of such differing claims is not straightforward. Several important considerations bear upon an assessment of the evidence regarding the adequacy of current interconnection. These are outlined below.

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| Box 18.1 Generators’ views on interconnectors |
| International Power-GDF Suez Australia stated that it only supported ‘rational interconnector investment that is underpinned by sound economic cost-benefit analyses’ (sub. 36, p. 9), but also noted that developments in the market might heighten the impact of congestion and increase the future importance of interconnection:  The NEM and the external environment have evolved to the point where we now see the progressively increasing impact of transmission issues on generator connection, network access, congestion and inter-regional trading. These issues have become even more critical as the market attempts to respond to the transformational challenges arising from the shift to clean energy. (sub. 36, pp. 8‑9)  The company also referred to the link between congestion and price volatility, and hence on the risks of trading between regions in the NEM (discussed in chapter 19):  The ability to trade power contracts between regions with confidence is a highly desirable outcome for the NEM. To do so currently requires a market participant to bear significant inter-regional price risk. …  Price differences themselves are not a problem, but rather their highly volatile nature. A major component of this volatility is introduced by transmission congestion – both within regions and between regions.  This overall price difference volatility is a deterrent to inter-regional trading. A generator or retailer that seeks to contract in a region outside its own faces significant risks if it is left unable to defend these contracts in the event of transmission congestion or inter-regional separation. (sub. 36, p. 9)  The National Generators Forum cautioned against the introduction of any requirements for transmission network service providers to undertake particular (interconnector) investment. The forum also considered that recent changes to the regulatory framework, particularly through the Regulatory Investment Test for Transmission (RIT‑T) mean that there is now:  … a robust and thorough assessment process to consider and measure the net efficiency gains from any interconnector project.  … the RIT-T, in combination with the incentives provided by the transmission building block regulatory regime, is capable of promoting timely and net beneficial transmission investment. (sub. 33, pp. 3, 5) |
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## 18.2 Some conceptual considerations

The benefits of interconnectors must be weighed against their costs. But while it is easy to understand the costs of an interconnector in engineering and financial terms, the benefits from greater interconnection are less tangible, and more varied. The RIT-T (discussed in more detail in chapter 17) contemplates a range of benefits that might arise from a new transmission investment (including interconnectors). These include allowing low cost generators to be dispatched more often, improvements in reliability, reductions in unserved demand, delayed or avoided investment in intra-regional transmission or generation assets, and the benefits from increased competition. The role of interconnection in managing congestion across the network is also important.

### Welfare effects from greater interconnection

By allowing interconnection between regions, an interconnector project can defer other transmission or generation investment. It can also improve productive and allocative efficiency in the interconnected market, by introducing further competition for generators, and enabling consumers to access more (and potentially cheaper) sources of energy.[[6]](#footnote-7)

While many of the effects would be transfers (for example, consumers in an exporting jurisdiction would likely face higher prices, while those in the importing jurisdiction would see price falls), with sufficient interconnection, there is likely to be a net welfare gain across the jurisdictions. This is best illustrated by a simplified example where a connection is introduced between previously unconnected low cost (exporting) and high cost (importing) regions (box 18.2).

At the same time, a welfare enhancing interconnection can create ‘winners and losers’ through its redistributive effects. Although these winners and losers generally ‘wash out’ in the assessment of a net benefit, their identification during the assessment process can be important. For example, the process of identifying beneficiaries is central to ‘beneficiary pays’ models of transmission expansion (see, for example, Hogan 2012a). Further, under certain circumstances a large transfer (with no net efficiency effects such as long-term investment incentives) from consumers to generators would not be consistent with the National Electricity Objective.

Net welfare effects (the change in consumer and producer surplus) are typically a reflection of movements in prices. In reality, such movements can occur for a variety of reasons. For example, if generation in neighbouring jurisdictions relies on fuel sources with different characteristics, price movements in those fuel sources can move in unrelated ways at different times. Connecting the regions can allow consumers to ‘smooth’ the costs, a point Turvey (2006) noted in commenting on a proposed interconnector between the largely hydro system of Norway and the largely thermal system of Britain:

In wet years such an interconnector would have added to total Norwegian export possibilities, so raising prices, while in dry years it would have extended the import possibilities, so reducing import costs; in other words there would have been a favourable terms of trade effect in some years. As regards daily variations on the other hand, the interconnector would have added to Norway’s capability for export using its hydro capacity, allowing it to earn more on peak power exports. (p. 1459)

While many of these effects will be reflected in movements in electricity prices, there will be exceptions. For instance, an interconnector might provide other benefits, such as avoiding generation investment required for security of supply (discussed below).

### An efficient level of congestion

Congestion in a transmission system can lead to higher electricity prices as potentially cheaper sources of generation are effectively disconnected from the market and progressively more expensive sources must be relied on to meet demand. This can also result in transient (or ‘time-limited’) market power for some generators. Should the generators respond to market incentives and decide to wield their market power, it could lead to further price spikes. Congestion can also affect reliability and result in load shedding if sufficient generation is not accessible in time to meet demand requirements. As such, reductions in congestion — through intra- or inter-regional transmission investment — can be beneficial.

However, congestion can be efficient The benefits of reducing congestion must be set against the investment and other costs of doing so. As the AEMC stressed in its Congestion Management review of 2008:

To eliminate *all* transmission congestion would be neither cost-effective nor efficient. It would lead to over-investment in transmission capacity. In the NEM’s radial network with dispersed sources of generation and centres of demand, the costs of building out all transmission congestion would be prohibitively high. There is, therefore, an *efficient level* of congestion … (2008b, p. 10)

The implication is that a lack of new investment in interconnectors does not automatically mean that the regulatory framework has ‘failed’ — it might simply be that the costs of alleviating identified congestion would outweigh the benefits. This in turn means that the regulatory framework should not be judged on the quantum of investment that does (or does not) go ahead. Rather, the pertinent questions are:

* Were efficient investments correctly identified and evaluated?
* Did only those investments that were judged as efficient go ahead?
* Did any investments that were judged as efficient *not* go ahead?

(Related issues are the categories of benefit that should be included, and the method of reaching judgments about the level of efficiency of any given investment. These questions are considered further in chapter 17.)

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| Box 18.2 Illustrative welfare effects from interconnection |
| Box 18.2 Figure 1 Illustrative welfare effects from interconnection. This figure compares welfare effects from interconnection on an exporting and importing region.  As the figure above illustrates, the introduction of an interconnector with a capacity of ‘K’ leads to some degree of price convergence, as the price rises to PA\* in the exporting region (region A) and falls to PB\* in the importing region (region B).  In terms of welfare effects, in the exporting region the higher price results in a loss to consumers (of surplus represented by the area ‘a+b’) but a gain to producers (‘a+b+c’), and a net welfare gain for the region (‘c’).  For the importing region, consumers gain from lower prices and associated greater consumption (‘d+e+f’), but the producers now receive a lower revenue through reductions in both quantity and ‘domestic production (the area ‘d’). Again, there is a net welfare gain to the importing region (‘e+f’), and an overall gain to both regions (‘c+e+f’).  There might also be dynamic efficiency gains if new generators can be built (and run) in one location at a lower cost than other locations. Those cost efficiencies might see the migration of investment to lower-cost generators, especially where the decisive factor is cheap fuel source availability. The point here is that ‘transfers’ can create rents (or losses) for generators that create incentives (or disincentives) for long-run investment and attempts to encourage cost minimisation. |
| *Source*: adapted from Kapff and Pelkmans (2010). |
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### Other potential benefits from interconnection

#### Encouraging financial trade in the energy market

Wholesale electricity spot prices are volatile, exposing generators and retailers to risk. As Parer et al. observed:

Irrespective of the level of interconnection, physical constraints between regions are of critical concern where they undermine the development of efficient levels of contracted interstate trade towards a truly national and efficient energy market and efficient integration of the NEM at a wholesale and retail level. The key issue is the ability of market participants to manage the financial risks that result from the potential for interconnects to physically constrain or fail. (2002, pp. 129‑30)

The Commission concurs that there could be benefits of this nature from greater interconnector capacity — though such capacity is only one factor affecting inter‑regional financial trading. Indeed, some other factors (such as market rules and participant behaviour) seemingly have more frequent and adverse effects on trading risk than the current capacity of interconnectors. These issues are explored further in chapter 19.

#### Accessing renewable fuel sources

Garnaut (2008) and others suggest that greater investment in renewable generation will increase the importance of interconnectors. For example, the Clean Energy Council submitted that:

High penetrations of renewable generation imply technology and geographic diversity. Under this condition cases are envisaged to arise where load and generation capacity will not always align within a region. In other words one region may have significant generation potential at a time when demand within that region is low and is exceeded by the generation capacity. To illustrate, if wind generation in South Australia exceeds overnight demand, the excess generation could be used in Victoria via interconnectors. (sub. 31, p. 5)

AEMO also pointed to the challenges that integrating renewable technologies, particularly wind energy can cause. AEMO went on to suggest that a national planner (who is capable of planning and directing both intra- and inter-regional transmission investment) was best suited to integrate government energy policies with the existing NEM in an efficient manner (sub. 32, p. 33).

Absent policies mandating a certain level of renewable energy use, the benefits of facilitating inter-regional flows of renewable energy would simply be one component of the overall benefits of trade in electricity across the NEM.

Where renewable energy sources are intrinsically efficient (that is, do not require subsidies) the ability to access them through interconnectors is likely to increase the scope for welfare enhancing trade of this nature as noted above. In this case, the benefits of interconnection are likely to be greater when neighbouring jurisdictions rely on different fuel sources. If fuel sources (and their associated costs) are largely the same, cost savings from greater interconnection might be smaller (but other impacts, such as mitigating any generator market power, benefits of scale of particular generators or reducing costs of meeting reliability requirements would still be present).

In the presence of current policies mandating a certain level of renewable energy, greater interconnection could have a more specific benefit through reducing the cost of meeting renewable energy requirements. In effect, interconnection will facilitate the use of the most cost-effective renewable resources across the NEM, rather than within each jurisdiction.[[7]](#footnote-8)

But this would be very much a second best benefit. To the extent that mandatory renewable energy targets impose net costs, the best policy would be to remove or reform them, not seek to alleviate that cost through further investment in interconnectors. (Some renewable energy schemes are discussed in the context of distributed generation in chapter 13.)

## 18.3 Evidence of the efficiency of interconnection

There is no single, conclusive measure to determine if interconnection in the NEM has reached (or is likely to remain at) an efficient level. Nevertheless, some indicators, in tandem, provide evidence on efficiency:

* cost–benefit analyses undertaken for potential interconnectors as part of RIT-T processes and in the National Transmission Network Development Plan (NTNDP)
* measures of the cost of congestion
* the level of price separations between regions in the NEM
* the extent of the utilisation of interconnector capacity.

### Cost–benefit analyses of potential interconnectors

Three interconnectors in the NEM (Heywood, QNI and Vic–NSW) are undergoing some evaluation by the relevant Transmission Network Service Providers (TNSPs), and AEMO in the case of Heywood, to determine what, if any, upgrades would be efficient. The information available from these analyses provides insights on both the adequacy of current interconnection capacity and the relative merits of different forms of upgrades (as well as on how the decision making process proceeds).[[8]](#footnote-9)

#### The RIT-T process for the Heywood interconnector

As the transmission planners for Victoria and South Australia respectively, AEMO and ElectraNet initiated a RIT-T for the Heywood interconnector following the identification of market benefits from such an expansion in the 2010 NTNDP. The first stage of the RIT-T process is a Project Specification Consultation Report (PSCR). This report (AEMO and ElectraNet 2011a) is designed primarily to facilitate consultation from interested parties by describing the ‘identified need’ (reason for new investment), ‘credible options’, and technical requirements for non-network solutions. In September 2012, AEMO and Electranet (2012) released the Project Assessment Draft Report (PADR) for the Heywood RIT-T. The PADR reported on cost–benefit analyses of six main options (and two minor variants to those options). Broadly, the PADR confirmed the outcome of an earlier feasibility study (AEMO and Electranet 2011b) and favoured the addition of a third transformer at the Heywood terminal station, which would increase the interconnector’s capacity from 460 to 650 MW. This option (‘1b’) was assessed as providing a net market benefit of $190 million (AEMO and ElectraNet 2012, p. ix).

However, another option (option 6b — involving similar additional work to option 1b, but with control schemes used instead of adding a third transformer) was found to have net benefits of $189 million (AEMO and ElectraNet 2012, p. ix). Although this option showed smaller benefits ($253 million as against $270 million), it also involved smaller costs ($64 million as against $80 million).

Although these options are estimated to have nearly identical net benefits, AEMO and ElectraNet noted that the control schemes involve additional risks (relating to technical feasibility and commercial issues such as the assignment of liabilities, among other things). In addition, the third transformer also provides benefits through limiting the reduction in the interconnector in the unlikely event of a failure of the existing transformers. Based on these additional considerations, AEMO and ElectraNet have identified the addition of a third transformer (option 1b) as the preferred option for increasing the capacity of the Heywood interconnector.

Importantly, the RIT-T assessment found that a larger increase in the capacity of interconnection between Victoria and South Australia (a new Krongart-Heywood interconnector which would increase overall capacity by 1940 MW) would be both costly ($212 million), and would not have substantially greater benefits ($303 million) than the preferred option. Accordingly, while still having a projected net benefit, the size of that benefit was less than half the preferred option (AEMO and ElectraNet 2012, pp. vii‑ix).

In January 2013, AEMO and Electranet (2013) released the Project Assessment Conclusions Report (PACR), the final stage of the Heywood RIT-T process. The PACR affirmed the choice of the third transformer at Heywood (option 1b). As no dispute was lodged with the AER by 22 February, Electranet will seek AER approval of the investment as a contingent project, and AEMO will put the Victorian components of the project to tender in the second half of 2013. The upgrade is expected to be operational in July 2016.

By indicating that a relatively incremental solution is likely to be the best option, the Heywood RIT-T process serves to illustrate that ‘bigger is not always better’, and provide a reminder that the costs of augmentation play a significant role in determining the net benefits that arise.

#### The RIT-T process for QNI

As with the Heywood RIT-T process, Powerlink and Transgrid recently published the PSCR for a potential upgrade to the QNI interconnector. The PSCR describes the identified credible options, and provides preliminary cost estimates and indicative figures for the increase in capacity associated with each option. They have not yet published cost–benefit analyses of the options.

However, this current process is not the first consideration of an expansion to the capacity of QNI. To date, the most significant increase in capacity on this interconnector has come about not from additional built network infrastructure, but rather from testing and refining control systems to use the existing infrastructure more efficiently (Powerlink and Transgrid 2012, p. 8). A previous application of the (then) regulatory test in 2008 concluded that the optimal timing of upgrades to QNI was (then) well into the future (Powerlink and Transgrid 2008, p. 3). In the PSCR, Powerlink and Transgrid note that various factors, including generation and load developments (as well as the RIT-T itself) have changed since the 2008 assessment, prompting a re-evaluation of potential upgrades (Powerlink and Transgrid 2012, p. 8).

This example highlights the ongoing nature of transmission planning, as well as the necessity to re-examine past forecasts in the face of changing conditions.

#### Cost–benefit analysis of ‘NEMLink’ in the National Transmission Network Development Plan

In addition to analyses carried out by transmission businesses in relation to their planned upgrades, AEMO — in its role as National Transmission Planner — separately publishes the NTNDP on an annual basis. The NTNDP involves consideration of increasing interconnection in the NEM through a conceptual project called NEMLink, which focuses on a high-capacity transmission ‘backbone’ through the NEM.

AEMO’s analysis suggests that building NEMLink would not be economically viable at this time. Indeed, the most economic option for the project — which defers the costly Victoria–Tasmania component of the link — is still judged to have a net cost (in 2010-11 dollars) of $400 million (AEMO 2011d, p. 6‑8).

AEMO went on to note that with increasing demand, NEMLink might become viable sooner under high demand and high carbon price conditions. However, a more likely scenario is that the project would only be viable in 15 to 20 years from now (AEMO 2011d, p. 6-1). Indeed, AEMO was sceptical that the project could be realised at all in the current environment of jurisdiction-based planning, even if it had a net benefit:

The NEM framework is incapable of delivering projects like NEMlink.

It would require significant coordination and cooperation of five transmission planners, alignment between the allowances in the revenue resets of each of the regulated businesses. The history of Inter-Regional Planning Committee (IRPC) suggests that such cooperation and coordination would not work in practice. (sub. 32, p. 32)

Nonetheless, AEMO’s analysis seems reasonably clear that, at this time, investment in this expensive project would not be economically efficient. More generally, it illustrates that the regulatory framework allows for the continued evaluation of the need for further interconnection, and only responding with investment when it is efficient to do so.

### The cost of congestion

While it is difficult to identify any single, efficient level of congestion, examining measures of congestion, and particularly their movement over time, can provide an indication of how well the regulatory and investment framework is working.

#### The ‘total cost of constraints’

The ‘total cost of constraints’ measures the impact of congestion in the NEM-wide transmission network as the total increase in the cost of producing electricity due to transmission congestion (which includes outages and network design limits) (AER 2009a, p. 142).[[9]](#footnote-10) The AER has also produced other estimates that focus only on congestion caused by network outages (the ‘outage cost of constraint’) and the marginal cost of constraint (that is, the saving in production costs if congestion on a transmission line is alleviated by one marginal MW of capacity).

The AER’s analysis suggested that the annual cost of congestion rose from $36 million in 2003‑04 to $189 million in 2007‑08, but fell to $83 million in 2008‑09. However, congestion was not uniform throughout any given year. Around two thirds of the total cost for 2007‑08 was accounted for by just 26 days, with nearly 60 per cent of the costs attributable to network outages. In 2008‑09 around two thirds of the total cost accrued on 13 days, with just over 40 per cent of the costs attributable to network outages (AER 2009a, p. 143). While it is difficult to isolate a sole cause for the substantial drop in the impact of congestion in 2008‑09, the AER considered that recent regulatory changes had encouraged additional investment (AER 2009a, p. 143).

The AEMC also found little evidence of costly congestion, with costs representing less than 0.5 per cent of the NEM’s total production costs in 2007‑08 (box 18.3 and AEMC 2008b, p. 15).

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| Box 18.3 Evidence in the AEMC’s 2008 Congestion Management Review |
| As part of its Congestion Management Review, the AEMC considered evidence from several sources on the pattern of ‘mispricing’, including the National Electricity Market Management Company Limited’s (NEMMCO) Statement of Opportunities – Annual National Transmission Statements, work conducted by Biggar and NEMMCO. The following were reported in the Review:   * Biggar concluded that the NEM-wide incidence of mispricing has increased since 2003‑04. He found that mispricing was a frequent and enduring issue at a relatively large number of connection points, stating that some 95 connection points were mispriced for an average of more than 100 hours per annum over the three years of his study (2003‑04 to 2005‑06).[[10]](#footnote-11) * NEMMCO’s preliminary study confirmed Biggar’s finding that there had been an increasing trend in mispricing from 2003‑04 onwards. However, it also showed that over the study period (2001‑02 to 2005‑06) the number of connection points being mispriced was fairly steady. NEMMCO noted that the reasons for these trends were specific to the region and the situation at the time. * Generators were significantly more likely to be positively mispriced (constrained-off) than negatively mispriced (constrained-on). In 2005‑06, the ratio between the two forms of mispricing was three to one. * For intervals classified as ‘mispriced’, the average mispriced amount per interval was very high, ranging from around $500 to $1000 per MWh for generators that were positively mispriced and from around -$300 to -$6000 per MWh for generators that were negatively mispriced. These results suggest there is a high probability that disorderly bidding occurred when a constraint bound. * Biggar found that only a small number of connection points were mispriced by more than $5/MWh for all three years of his study. These connection points all related to small gas or hydro plants in Queensland. * Biggar also found that average hours of mispricing due to system normal events were fairly constant over the three years, at around 50 hours per year. However, there was an increasing trend in the duration of mispricing due to transmission outages, from 20 hours in 2003‑04 to over 120 hours in 2005‑06. This was mainly due to the increased incidence of outage-caused congestion in both the Snowy and Queensland regions. The Queensland increase was due to lightning events affecting flows between Central and South Queensland and an outage at the Gladstone transformer. |
| *Source*: AEMC (2008b). |
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### Price separations in the National Electricity Market

In theory, complete integration of the regions in the NEM would result in equal prices across the NEM (allowing for differences in transmission losses). However, because some congestion is optimal, sporadic interregional price differences (or ‘price separations’) are not necessarily inefficient.

The evidence in relation to frequency, scale and impacts of price separations is mixed. Most studies have focused on frequency of occurrence rather than the impacts of separations, the latter being of greater concern. For example, evidence provided by the National Generators Forum (NGF, sub. 33) suggests that in the relatively infrequent number of cases where interconnector congestion is encountered (figure 18.4), the resulting price differences are typically small. Specifically, in more than 90 per cent of such congestion events in 2010‑11, the price difference was less than $50 per MWh (table 18.2).

Figure 18.4 Percentage of interconnector time constrained, 2010-11

Per cent of half hour periods

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| Figure 18.4 Percentage of interconnector time constrained, 2010-11. This figure comprises of four pie charts which show the percentage of constraints on lines from Queensland to New South Wales, Victoria to South Australia, New South Wales to Victoria and from Victoria to Tasmania.  Into Tas 20.23  Into Vic 13.21  Unconstrained 66.56  Into Vic 1.78  Into NSW 12.37  Unconstrained 85.85  Into Vic 6.63  Into SA 17.15  Unconstrained 76.21  Into Qld 1.14  Into NSW 19.23  Unconstrained 79.63 |

*Data source*: NGF (sub. 33, p. 6).

Table 18.2 Price separations by interconnector, 2010‑11

Share of separations (%)a, by price category

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Line/direction | <$0 | $0<$50 | $50<$100 | $100<$200 | $200<$500 | $500<$1000 | $1000<$12,500 |
| QNI - to Qld | 0.8 | 95.8 | 1.3 | 0.3 | 0.3 | 1.3 | 0.3 |
| - to NSW | 0.8 | 97.9 | 0.5 | 0.2 | 0.1 | 0.1 | 0.4 |
| Vic-SA - to SA | 70.7 | 27.9 | 0.3 | 0.2 | 0.5 | 0.1 | 0.3 |
| - to Vic | 1.9 | 93.0 | 3.0 | 0.5 | 0.4 | 0.3 | 1.0 |
| Vic-NSW - to NSW | 0.9 | 94.1 | 1.8 | 0.9 | 1.5 | 0.1 | 0.6 |
| - to Vic | 0.0 | 99.5 | 0.4 | 0.0 | 0.1 | 0.0 | 0.1 |
| Basslink - to Vic | 2.9 | 94.9 | 0.9 | 0.4 | 0.7 | 0.1 | 0.2 |
| - to Tas | 2.5 | 94.9 | 2.1 | 0.1 | 0.3 | 0.0 | 0.2 |

a Shares have been rounded to one decimal place.

*Source*: adapted from NGF (sub. 33, pp. 9‑10).

The NGF also reported that the percentage of half hours when price separation was less than $10 ranged from 95 per cent on Basslink, to 62 per cent from New South Wales to Victoria (sub. 33, p. 7).

The Commission notes that while the figures submitted by the NGF report a low *frequency* of price separations, and particularly of incidents of greater separation, the information submitted does not (nor does it attempt to) reflect the *effect* of those separations.[[11]](#footnote-12) Further, these data represent a ‘snapshot’ of separations.

Conversely, according to the AER, alignment of prices between regions (allowing for small differences due to natural transmission losses over long distances) is becoming less common. Prices were aligned 80 per cent of the time in 2001‑02, 67 per cent in 2009‑10 and only 61 per cent of the time in 2010‑11 (AER 2011b, p. 34). This trend in the data could suggest increasing cause for concern regarding price separations (and that caution is required in drawing overly strong conclusions from the sort of snapshot data submitted by the NGF). However, as with the data submitted by the NGF, this alignment only examines the frequency of separation, not the effect that such separations have on broader market outcomes (such as counter price flows and on hedge markets) — the latter being more important for the efficient operation of the NEM. Indeed, multiple separations of little to no impact can be of less concern than isolated, unpredictable, instances of large separations — depending on their effect on consumer behaviour, production and investment decisions, and risk management.

Recently, the AER (2012t) published further analysis regarding the costs caused by so-called ‘disorderly bidding’. This arises when, in the presence of congestion, generators’ bidding behaviour can increase the price in one region, while simultaneously causing ‘counter-flows’ (wherein power flows from the high-priced region to the low-priced region) across the interconnectors. That is, the behaviour of generators can cause, or exacerbate the effect of, price separations. The resulting counter-flows can occur at times when there is significant price separation (greater than $100/MWh) between regions, and gives rise to substantial costs that must be borne by consumers. Disorderly bidding and the AER’s analysis of the costs from particular instances are discussed further in chapter 19.

### There are unusual patterns in the utilisation of interconnectors

The economic effects (including price impacts) of interconnectors are determined by the amount of power transported across regions (utilisation), not the built capacity of interconnector. Utilisation often appears to be relatively low.

One example of this was highlighted by the Energy Users Association of Australia (sub. 24). Up to 2006, the Heywood and Murraylink interconnectors supplied around a 20 per cent (aggregate annual) share of South Australia’s electricity, ‘but since then it has ranged between almost no share and a 5 per cent share, although gradually increasing since 2007’ (EUAA, sub. 24, p. 15). Paradoxically, the share of power supplied appeared to drop at the times when the interconnectors would be expected to be flowing at capacity. The average share of the electricity supplied through the interconnectors, during the 72 highest price half-hourly settlement periods (that is, peak times) from 2008 to 2010, was around 10 per cent (EUAA, sub. 24, p. 14).

The EUAA further examined the interconnector capacity in both peak and average annual terms (table 18.3). It found that even during the hot years of 2008 and 2009 the interconnectors’ utilisation was only ‘a little over half’ of their capacity (sub. 24, p. 16). Yet, during these years, the highest 72 half-hourly settlement prices in South Australia were never less than $376 per MWh, and averaged $7180 per MWh.

Table 18.3 South Australian interconnector capacity factors

Heywood and Murraylink, shares of peak annual transfer capacity, per cent.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Year | Capacity factor a in highest  72 settlement periods | | Average annual capacity factor | |
|  | *Vic to SA* | *SA to Vic* | *Vic to SA* | *SA to Vic* |
| 2005 | 39 | 33 | 41 | 2 |
| 2006 | 46 | 2 | 40 | 3 |
| 2007 | 8 | 33 | 13 | 19 |
| 2008 | 54 | 4 | 14 | 18 |
| 2009 | 52 | 6 | 20 | 16 |
| 2010 | 41 | 8 | 23 | 14 |
| 2011 | 55 | 4 | 27 | 11 |
| **Average** | **42** | **13** | **25** | **12** |

a ‘Capacity factor’ refers to the utilisation of the interconnectors as a percentage share of their listed capacity.

*Source*: EUAA (sub. 24, p. 16).

Several factors might explain these seemingly odd outcomes. For example:

* high prices in South Australia might have coincided with high prices in Victoria, in which case below-capacity flow on the interconnector would be efficient
* a physical constraint on the interconnectors themselves, or elsewhere in the transmission network, might have constrained the interconnector flow to below the listed capacity

Another issue is that generating capacity in South Australia might have been withheld (the view of the EUAA (sub. 24, p. 17), which found that surplus generation capacity was available at times of very high prices). The potential withholding of capacity was one of the issues examined by the AEMC (2012m) in its Rule change regarding potential generator market power in the NEM. In its draft rule determination, the AEMC found that:

… there is a noticeable reduction in capacity utilisation in South Australia at prices above $250/MWh. This reduction contrasts with much smaller reductions or even increases in the other NEM regions. While there are myriad reasons as to why levels of capacity utilisation at high prices are lower in South Australia, including more frequent outages or the responsiveness of generation plant, it is of note that the primary driver of the fall in South Australian capacity utilisation when prices are above $250/MWh is AGL’s operation of the Torrens Island power station. (2012m, pp. 41‑2)

The AER also highlighted the behaviour of the Torrens Island Power Station:

In only two of the 26 half hour periods where price exceeded $5000/MWh was more than 700 MW of the Torrens Island’s capacity dispatched (Torrens Island Power Station’s total capacity is 1280 MW). In over a third of these half hourly periods, *under 300 MW* of the total capacity of Torrens Island was dispatched. (2012i, p. 10)

In his examination of the exercise of market power in the NEM, Biggar also concluded that ‘out of 57 high-demand days, on 30 occasions [Torrens Island Power Station] appears to have been directly exercising market power with withholding capacity’ (2011c, p. 49).

More generally, the issue of generator market power in South Australia has been the subject of substantial commentary, including as part of the AEMC’s Rule change process (box 18.4). While the AEMC acknowledged factors that led to positions of market power, they concluded that any exercise of market power was likely to be *transient* (that is, took advantage of temporary conditions), and not substantial.[[12]](#footnote-13) However, some others were more concerned. For example, as part of the Rule change process, the AER submitted that ‘it appears that there has been the exercise of substantial market power, particularly in South Australia’ (2012i, p. 1). And, in Biggar’s view, there had been a ‘significant’ exercise of market power that ‘persisted for three consecutive summers’ (2011c, p. 61).

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| Box 18.4 Generator market power in South Australia – the AEMC’s view |
| In examining the issue of generator market power in the NEM, the AEMC (2012m) found that in South Australia there was:   * some evidence of barriers to entry — one pre-condition for firms to *possess* market power, itself a pre-condition to *using* that market power (p. 42) * some concern regarding the level of market concentration (p. 41) * a lower level of contract (or hedge) market liquidity than in other NEM regions (p. 43), and limited transparency with regard to prices and volumes of trade in the contract market due to vertical integration (p. 21) * wholesale annual average spot prices above a range of long‑run marginal costs estimates in 2007-08, attributed to restricted interconnector flow. Prices fell just below the ‘high’ end of long‑run marginal cost estimates, before falling below the range in 2010-11 (p. 28).   Overall, the AEMC concluded that there was insufficient evidence of *substantial* (as distinct from ‘transient’) market power in the NEM, and (at the draft stage) did not agree with the proposed rule. They did note, however, that work undertaken on their behalf by the Competition Economists Group suggested that in South Australia ‘there was evidence that meant that ongoing monitoring of prices against the long‑run efficient level may be warranted’ (AEMC 2012m, pp. ii‑iii). |
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|  |

The EUAA (sub. 24) argued that a benefit of expanding interconnector capacity would be to promote competition between generators, eroding potential positions of market power. Clearly, a base level of interconnector capacity is necessary to facilitate inter‑regional competition. However, given that in the particular circumstances of concern to the EUAA and others there is currently spare interconnector capacity, it seems unlikely that upgrading those interconnectors, or upgrading intra-regional lines that would increase effective capacity of the interconnectors, would be the sole solution (that is not to say that upgrading the degree of physical interconnection cannot be beneficial, as identified in the RIT-T analyses discussed above). A potentially more fruitful approach would involve reforms to market design to encourage more efficient bidding behaviour by market participants (chapter 19). This would in turn facilitate more efficient interconnector utilisation, and allow for more accurate decisions about the necessity of any interconnector expansion.

### Conclusion

Investment in interconnectors to date appears to have provided a reasonably appropriate level of physical capacity to enable trading in power between regions (given current network, generation and demand profiles). That conclusion can be reconciled with the existence of congestion at times because — as the cost–benefit analyses that have been done suggest — in most cases there would be significant net costs from eliminating this congestion. And where net benefits have been identified, such as in an expansion of the Heywood interconnector, the relevant stakeholders are acting to initiate further investment.

Following the draft report, several participants — such as the AEMC (sub. DR89), Grid Australia (sub. DR91), the AER (sub. DR92), the NGF (sub. DR93) and AEMO (sub. DR100) — broadly agreed with the Commission’s conclusions on the capacity for interconnection and the issues surrounding the use of interconnectors (finding 18.1).[[13]](#footnote-14)

Finding 18.1

The available evidence suggests that, given the existing network conditions, the current physical capacity for interconnection is appropriate.

However, that the current physical capacity is reasonably appropriate does not necessarily mean that all market, planning, regulatory and incentive settings into the future are optimal. Nor does it mean that interconnectors are performing their intended role as efficiently as possible. Indeed, several concerns remain.

First, price separations can pose a problem. Substantial price differences between regions are infrequent, but isolated instances of large price differences can have significant adverse effects (including causing counter‑flows on interconnectors, and complicating hedging arrangements).

Moreover, the physical capacity of interconnectors is not the sole determinant of the actual flows of power between regions in the NEM. Accordingly, the apparent under-utilisation of some interconnectors is not necessarily an indication of current excess capacity. Market design (including rules governing bidding), and participant behaviour in response to the incentives created by the market rules, can affect the use of interconnectors. Current underutilisation may create a distorted base for future projections of interconnection needs.

Further, an assessment that the current level of interconnection is reasonably satisfactory does not necessarily mean that the existing regulatory framework will continue to deliver efficient interconnection into the future. Making judgments of efficiency based on the application of the RIT-T assumes that the test is an accurate and appropriate basis for making such decisions, an assumption that warrants examination (chapter 17).

Therefore, in order to judge if the regulatory framework will continue to deliver efficient interconnection, the Commission considers that, beyond assessments of physical capacity, it is important to examine:

* if the installed capacity is being used efficiently and if not, what could remedy this? (chapter 19)
* whether, outside of the regulatory regime, there are any barriers that prevent the future provision of privately initiated (or ‘merchant’) interconnection? (chapter 20).

1. Which states that ‘if parallel paths exist in an AC electricity network, the total flow between A and B will be distributed among the parallel paths from A to B in inverse proportion to the resistance along those paths’ (Pollitt 2011, p. 9). In effect, if there are multiple paths for electricity to travel along between two points, then the electricity will take all the paths (in differing shares), rather than any single path. This increases the likelihood that congestion on any one line will affect other lines in the network. [↑](#footnote-ref-2)
2. *Radial* networks are characterised by power travelling in one direction from supply to load along a large ‘trunk’ line, with lower voltage lines branching out from the central line. *Meshed* networks contain additional lines, creating a ‘web’ of several different routes, so that power can travel between any two points, forming some loops within the system (von Meier 2006, p. 150). [↑](#footnote-ref-3)
3. That is, the amount of power that can be transferred on interconnector infrastructure before that interconnector is constrained. [↑](#footnote-ref-4)
4. The capacity of direct current (DC) interconnectors (such as Basslink) in an AC system can be more easily determined, as power must be converted from, and back to, AC in order to travel along the DC link. As the amount of power that needs to be converted is known, and controlled, it is simpler to determine the amount that flows along the DC component of the line. [↑](#footnote-ref-5)
5. Settlement residue auctions are described in chapter 19. [↑](#footnote-ref-6)
6. ‘Cheaper’ in this instance refers to savings in fuel and other variable operating costs. Greater interconnection can also allow for more flexibility of choice in regard to generators, potentially avoiding or reducing ‘start up’ costs incurred from bringing additional peak generators online. [↑](#footnote-ref-7)
7. There could still be gains from trading between regions, even in the presence of distorting state‑based schemes. However, greater gains from trade (and potentially different trade patterns) would be available if there were no distortions at state level. [↑](#footnote-ref-8)
8. Electranet and AEMO published a Project Specification Consultation Report (PSCR) examining potential upgrades to the Heywood interconnector in October 2011, a Project Assessment Draft Report in September 2012, and a Project Assessment Conclusion Report in January 2013**.** Powerlink and Transgrid published a PSCR examining QNI (the Queensland–New South Wales Interconnector) in June 2012, and the AER (sub. 13, p. 25) advised that AEMO and Transgrid have ‘indicated they intend to investigate the benefits of upgrading the Victoria to New South Wales interconnector. The analysis for this investigation is not yet public’. [↑](#footnote-ref-9)
9. The AER published four annual reports on congestion from 2003-04 to 2006-07. The reports were an input into the development of a new parameter in the service target performance incentive scheme for transmission companies. The parameter was first applied in 2009 (AER 2009a, p. 143). [↑](#footnote-ref-10)
10. The AEMC note that, in the presence of congestion, the (implied) local price offered by a generator and the regional price can diverge. They term this phenomenon ‘mispricing’, which creates dispatch risk and leads to disorderly bidding (AEMC 2008b, p. 8). [↑](#footnote-ref-11)
11. For example, while a separation of up to $12 500 for flows into New South Wales on the Victoria–New South Wales interconnector appears to be roughly 150 times less frequent than those under $50, if the difference in price on those occasions is, say $12 450 as against $49 (250 times larger), then the economic impact would be considerably higher. It may also be the case that larger price differences tend to occur more often at peak times, increasing the quantity of power involved and thus exacerbating the impact of a given price difference. [↑](#footnote-ref-12)
12. Importantly, this discussion considers only the *exercise* of market power, not its *misuse*. As such, the discussion here (and in the sources referred to) is not concerned with proving an offence under the Competition and Consumer Act 2010. [↑](#footnote-ref-13)
13. While agreeing that market design issues were inhibiting efficient interconnector use, AEMO (sub. DR100) also cautioned against making a definitive conclusion on interconnector capacity, and the underlying (state-based) networks until after the market design issues were resolved. [↑](#footnote-ref-14)