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Historical analysis of coordination between transmission and generation investment in the NEM

A South Australian case study for the Australian Energy Market Commission

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1. Introduction

This report has been prepared for the Australian Energy Market Commission (AEMC) as part of the AEMC's wider consideration of the Optional Firm Access (OFA) model, as directed by the Standing Council of Energy and Resources (SCER).[1]

This report presents a discrete case study looking at the historical coordination of transmission and generation investment in South Australia, paying particular attention to the locational decisions of wind farms in the state. South Australia provides an interesting case study to assess the degree to which locational factors have influenced investment decisions for new generators, because of the numerous wind farms that have been constructed in the region over more than a decade. A number of parties have expressed the view that in the absence of a locational pricing signal some wind farms have been constructed in locations that have increased congestion and so resulted in inefficient outcomes.

Specifically, the AEMC has asked us to investigate whether or not there is historical evidence of inefficient locational decisions being made by two sets of generators in South Australia – namely:

1. Wind farms locating in the south east region of South Australia; and
2. Wind farms locating in the mid-north region of South Australia.

In putting together this report we have undertaken an extensive consultation process with stakeholders to hear their views as to whether there is any historical evidence of inefficient locational decisions being made by wind farms in each of these regions, as well as in South Australia more generally. This report does not undertake an explicit assessment of efficiency but instead provides the research and background that would feed into this type of assessment.

The structure of this report is as follows:

- Section 2 provides a brief history of the historical development of transmission and generation in South Australia since the start of the NEM;
- Section 3 provides a discussion of the analysis that might be undertaken to determine whether a locational decision by a generator is 'efficient';
- Section 4 presents the findings of our discussions with stakeholders focusing on whether or not there is historical evidence of inefficient locational decisions by generators in South Australia; and
- Section 5 presents an indicative quantitative analysis looking at the effects of locational decisions by generators within the vicinity of the Heywood interconnector.

[1] This report is an amended version of the original report provided to the AEMC, dated 2 February 2015. We amended the original version to clarify the limitations of the quantitative analysis undertaken in section 5, and to clarify the conclusions that can be drawn from that quantitative analysis. We have also amended a factual error regarding network support payments at Port Lincoln.

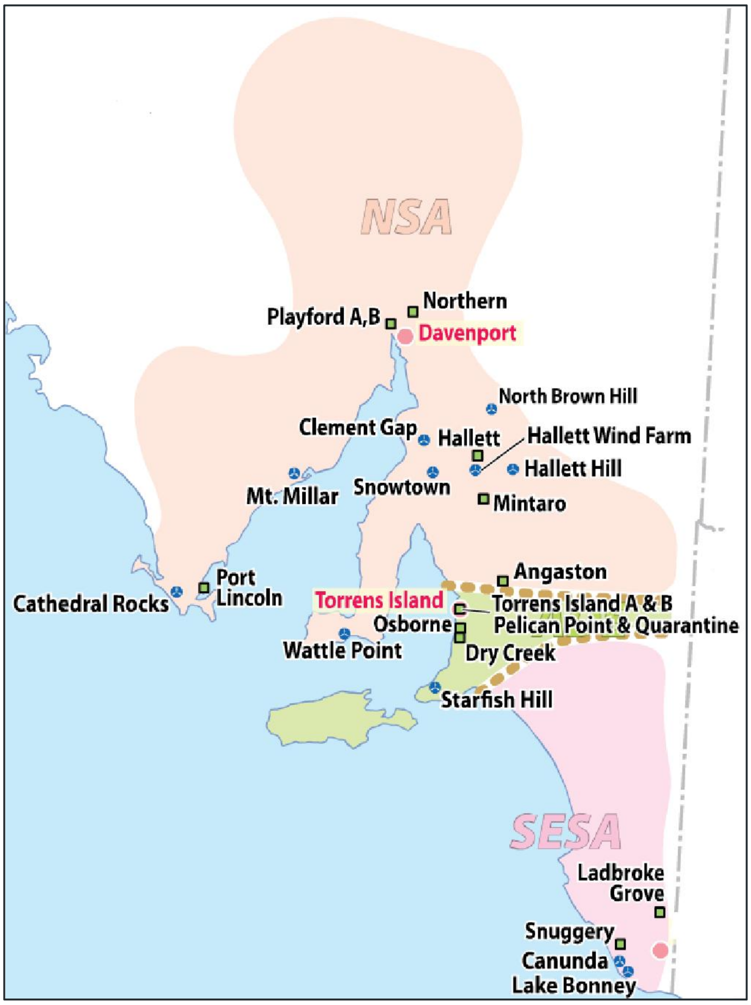
2. Development of transmission and generation in South Australia

Before discussing the two sets of generator locational decisions the AEMC has asked us to investigate, it is useful to first provide a brief history of transmission and generation development in South Australia.

2.1 Generation assets in South Australia

Figure 1 below illustrates the location of all existing power stations in South Australia, by National Transmission Network Development Plan (NTNDP) region – where northern South Australia (or 'NSA') is shown in orange; Adelaide (or 'ADE') is shown in green; and south eastern South Australia (or 'SESA') is shown in pink. We have been asked to investigate the locational decisions of two sets of wind farms: Canunda and Lake Bonney in the SESA region, and the wind farms around Hallett in the mid-north region.

Figure 1: Location of existing power stations in South Australia, by NTNDP region



Source: AEMO interactive network map, available at: http://www.aemo.com.au/Electricity/Planning/Archive-of-previous-Planning-reports/2010-NTNDP/2010-NTNDP-Data-and-Supporting-Information/Main-Report/Interactive-Map

Table 1 below shows each of the generating units that have been commissioned in South Australia since the start of the National Electricity Market (NEM) in 1998 by type, size and location. We note that a number of significant power stations were commissioned in South Australia prior to NEM-start that are currently operating, including Torrens Island (the largest power station in South Australia) and Northern, and so are not reflected in the table below. Table 1 shows that since 2003, some 1,500MW of wind farm capacity has been commissioned in South Australia (representing over 30 per cent of total installed capacity).

Table 1: Power station commissioned in South Australia since NEM-start that currently operate

Station	Location*	Commissioned	Technology	Capacity (MW)
OSBORNE	ADE	1998	CCGT	180
PORT-LINCOLN	NSA	1999	OCGT	50
LADBROKE-GROVE	SESA	2000	CCGT	80
PELICAN-POINT	ADE	2000	CCGT	478
HALLETT	NSA	2002	CCGT	180
QUARANTINE	ADE	2002	OCGT	224
STARFISH-HILL-WIND-FARM	ADE	2003	WIND	35
CANUNDA-WIND-FARM	SESA	2005	WIND	46
CATHEDRAL-ROCKS-WIND-FARM	NSA	2005	WIND	66
LAKE-BONNEY-WIND-FARM	SESA	2005	WIND	81
MT-MILLAR-WIND-FARM	NSA	2005	WIND	70
WATTLE-POINT-WIND-FARM	NSA	2005	WIND	91
LAKE-BONNEY-2-WIND-FARM	SESA	2008	WIND	159
SNOWTOWN-WIND-FARM	NSA	2008	WIND	99
CLEMENTS-GAP-WIND-FARM	NSA	2010	WIND	57
HALLETT-5-WIND-FARM	NSA	2011	WIND	71
HALLETT-1-WIND-FARM	NSA	2011	WIND	189
LAKE-BONNEY-3-WIND-FARM	SESA	2011	WIND	39
SNOWTOWN-2-NORTH	ADE	2011	WIND	148
SNOWTOWN-2-SOUTH	ADE	2011	WIND	126
WATERLOO	NSA	2011	WIND	111
HALLETT-4-WIND-FARM	ADE	2011	WIND	132
HALLETT-5-WIND-FARM	NSA	2012	WIND	53

Source: HoustonKemp internal database with data sourced from NTNDP data.
** Locations are expressed in NTNDP notation, which Figure 1 illustrates.*

We note that in recent years there have been a number of significant announcements regarding the scaling back of operations at a number of large thermal power stations in South Australia. In particular:

- In April 2012, Alinta Energy announced that both Northern and Playford Power Stations would (for a transitional period) only operate from October to March. While Northern Power Station is now operating one unit through the winter, Playford Power Station remains on 90-day recall for system security.[2]
- Last year, AGL announced that it will retire the generating units at Torrens Island A in 2017.

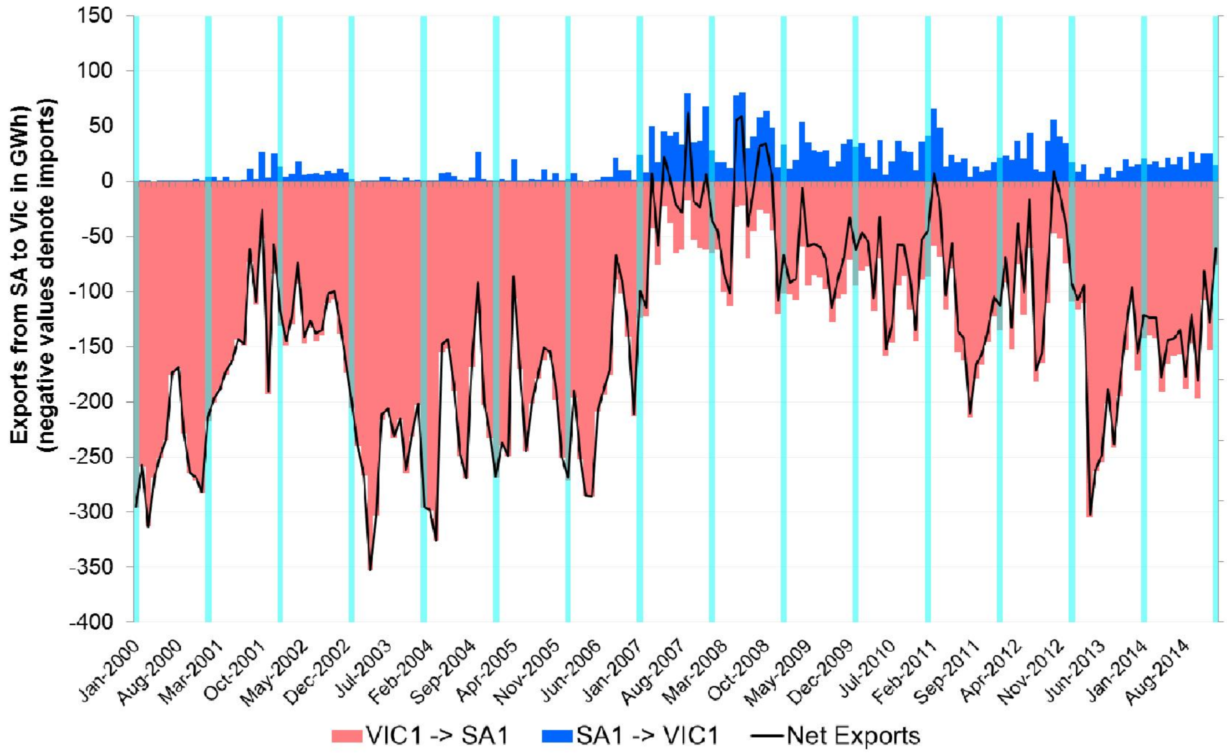
[2] Alinta website, available at: https://alintaenergy.com.au/about-us/news/northern-power-station-to-operate-through-winter

2.2 The Heywood Interconnector

The Heywood Interconnector is located between the substations in south east South Australia and Heywood (in Victoria). Historically, Heywood has predominantly been used to import power into South Australia from Victoria. However, the increasing penetration of wind farms in South Australia has resulted in Heywood exporting power from South Australia.

Figure 2 below shows the exports from South Australia (in blue) and the imports from Victoria (in red) since January 2000, as well as the net exports of energy over this period (solid black line). The sharp increase in exports from around the end of 2005 is largely a result of the wind generation coming online in South Australia from this date. The recent reduction in imports shows the effect of Northern power station coming back online from only being operated seasonally.

Figure 2: Exports from SA to Victoria over Heywood + Murraylink by Month (GWh)



In February 2011, ElectraNet and AEMO published the results of a joint feasibility study regarding an upgrade of the Heywood interconnector. The aim of the study was to assess the potential economic benefits from increasing the transfer capacity between South Australia and the rest of the NEM. An increase in interconnector capacity was considered to provide South Australia with the potential for increased access to reliable, lower cost thermal generation from the rest of the NEM, particularly at peak times, and also enable further development of South Australia's renewable generation resources.

The 2011 study found that:

- There was potential to augment transmission capacity between South Australia and the rest of the NEM; and
- An incremental upgrade to the existing interconnector showed the largest net economic benefit.

The 2011 study was followed by a formal Regulatory Investment Test for Transmission (RIT-T) process conducted jointly by ElectraNet and AEMO. This process identified two main limitations of the Heywood interconnector, ie:[3]

- The thermal capabilities and voltage stability limitations in south-east South Australia; and
- The transformer capacity at Heywood.

ElectraNet and AEMO stated that alleviating both these limitations would increase the import and export capability of the interconnection.

The RIT-T process concluded in January 2013 and resulted in a significant upgrade to the interconnector which is currently being undertaken. There are three components to the Heywood interconnector upgrade currently being implemented, ie:

1. Reconfiguring the 132kV network in the south east region of South Australia;
2. Series compensation on the 275kV network in the south east region of South Australia to resolve the voltage stability constraint; and
3. Installing a third transformer at Heywood.

We understand from discussions with ElectraNet that the first two components are aimed at increasing the ability of South Australia to export wind generation, while the third component will increase the Heywood interconnector's capability to transmit energy from Victoria to South Australia at peak times. The upgrade is expected to expand the interconnector capacity by approximately 190MW (in both directions) and is expected to be completed in July 2016.

The RIT-T assessment was made assuming future locational decisions of wind farms (and other generator types) consistent with current market conditions. The RIT-T did not assess whether the net market benefits from any of the options investigated would have been higher (or lower) if proponents of future wind farms had pursued development sites elsewhere within South Australia, eg, because of the locational price signals arising under OFA.

[3] ElectraNet and AEMO, *South Australia – Victoria (Heywood) Interconnector Upgrade*, Project Assessment Conclusions Report, January 2013, p. I.

3. Framework to assess efficiency of locational decisions

This section describes the economic concept of efficiency, and then sets out a framework for determining whether a particular locational decision by a generator can be considered to be efficient.

For the purposes of illustration, this section discusses the framework in the South Australian context and the two examples provided by the AEMC as representing potentially inefficient generator locational decisions.

3.1 Concept of 'efficiency' and overview of assessment framework

In economic terms, an 'efficient' outcome or option is one that represents a state of the world where no party can be made better off without making another party worse off. Put another way, an efficient outcome is one where the net benefit across *all* parties is maximised, ie, the selection of any other outcome would have resulted in a lower net benefit across all parties (whether or not the net benefits to a *particular* party are maximised is not an efficiency consideration). In assessing the efficiency of a generator locational decision, the efficient outcome is the one that maximises the net benefit estimated across all those who produce, consume and transport electricity in the market.

An assessment of the efficiency of a specific outcome therefore requires the comparison of the actual outcome (sometimes called the 'base case') with an alternative outcome (or outcomes). If the net benefits of the base case exceed those of the alternative outcomes, then the outcome is efficient. In contrast, if there exists an alternative outcome where the net benefits exceed those of the base case, then the base case is inefficient.

The location decision of a generator can be expected to potentially affect the following, in particular:

- The output of other generators;
- Investment in other generation (possibly both the timing and type of investment made); and
- Investment in the transmission network (again, both the timing and type of investment made).

The following sections describe the three steps we would expect to see in any assessment of the efficiency of a generator's locational decision, ie:

- Step 1: Identification of alternative generator location options;
- Step 2: Develop market scenarios; and
- Step 3: Estimating relevant costs and benefits.

3.2 Step 1: Identification of alternative generator location options

As noted above, to determine whether or not a particular outcome (eg, a generator locational decision (or set of generator location decisions)), is 'efficient' or not, one must first identify at least one other outcome (or state of the world) that the outcome in question can be compared to. An assessment of efficiency is then typically done by comparing the state of the world with the outcome in it to the state of the world without the outcome in it, ie, a 'with and without' analysis.

The simplest assessment of efficiency can be made by comparing the particular generator locational decision in question against the state of the world where the generator chooses to not locate at all. If the net benefit, estimated across all those in the relevant market, is lower for the generator location in question relative to the state of the world with the generator choosing to locate not at all it suggests that the generator locational decision is inefficient.

However, a more thorough consideration of the efficiency of a particular generator locational decision is to assume that the generator in question locates elsewhere (as opposed to not at all). This is also a more realistic assessment in the case of wind farm locational decisions as they would still be likely to locate somewhere, as a result of the incentives provided by the Large-scale Renewable Energy Target (LRET). These alternative geographic location options need to be identified as part of the assessment, eg, the wind farms choose to locate in a different region of South Australia or a different region of the NEM.

In the case of the two different sets of wind farms that form the basis of this report, the alternative outcomes would be either for proponents of the wind farms to:

- Choose to locate in a different region of South Australia; or
- Choose to locate in a different region of the NEM (eg, Victoria).

Overall, the number and nature of options being examined will be specific to each case being investigated.

We note that it may be a worthwhile exercise to consider where generators would have located if a mechanism like the OFA model were in place and to base the characterisation of options off this consideration. However, the purpose of the paper is not to consider the exact mechanism which would result in wind farms choosing to locate somewhere else, but to instead acknowledge that other locations need to be identified in order for a meaningful assessment of the efficiency of locational decisions to be made.

3.3 Step 2: Develop market scenarios

It is important that any assessment of efficiency considers a range of different scenarios for how the market may develop in the future, prior to estimating the associated costs and benefits of the options estimated in step 1 above. Similar to the requirements under the Regulatory Investment Test for Transmission (RIT-T), we would expect that each scenario reflects changes in parameters or variables that are expected to affect the net market benefit of different options, such that the ranking of these options changes or the sign of the net market benefit changes (i.e. from positive to negative, or vice versa).

Reasonable scenarios therefore may include the following:

- Sensitivity tests on key parameters (with each scenario reflecting different values for the parameter being tested); and
- Different assumptions about the future development of demand.

Each scenario developed is used to derive the pattern of investment in and dispatch outcomes in the NEM, which in turn are used to estimate market benefits for each option.

Overall, the net market benefits of each option used for assessing efficiency should be the probability weighted net market benefits for that option across all scenarios investigated. Where there is no material evidence for assigning a higher probability for one scenario over another, all scenarios should be weighted equally in this assessment.

3.4 Step 3: Estimating relevant costs and benefits

Given the test of efficiency is that the option must be estimated to have the greatest net benefits to the market across all options considered, we would expect that any assessment of the efficiency of a generator locational decision would estimate the following categories of market benefit over the assessment period, for each option:[4]

[4] We note that these categories of benefits generally accord with those prescribed in the NER for the RIT-T applying to electricity transmission development.

- The total costs associated with generator dispatch, which captures the impact of that option on the output of other generators;
- The total capital and operating costs of investment of new generating plants, which would capture the impact of that option on future generation investment;
- The total capital and operating costs associated with new transmission investment, which picks up the interaction between the locational decisions of a generator and the transmission investment may then be required (eg, to relieve congestion created by the generator's location);
- Any impact on the total cost to the market associated with unserved energy, both voluntary[5] and involuntary.
- The value of network losses across the market;
- The cost of ancillary services. For example, if an option increases in the dispatch of intermittent generation (ie, wind), then it is likely that there will be changes in ancillary service costs as there will need to be more ancillary services to manage the increased uncertainty;
- The benefits (costs) associated with an increase (decrease) in the competitiveness of generator wholesale bidding behaviour, as a result of the locational decision of the generator;
- The benefits (costs) associated with any increase in retail competition, as a result of retailers having greater (less) access to hedging products in a particular region, as a result of the generator's locational decision.

We note that each of these benefits/cost streams should be converted to present value terms to take account of the various timing of costs and benefits under each option.

Estimating the impact on each of these categories for each option aims to capture the effects of a particular generator locational decision on all relevant parties in the NEM. As noted above, where the NEM *with* the particular locational decision by a generator in question is estimated to have a lower net market benefit than the NEM estimated *without* that particular locational decision by the generator in question (ie, where it the generator was located elsewhere or not at all), that particular locational decision would be considered 'inefficient'.

We note that a particular generator locational decision may have a number of detrimental impacts on competing generators but it is important to realise that these impacts may not represent an inefficiency overall. For example, if a new entrant generator locates in an area with existing generators and, through having a lower short run marginal cost, displaces those generators by encroaching on the access they previously had then this may well be an efficient outcome.

The simplest method to compare the net market benefits of an option to the base case is to do so implicitly, ie, to estimate each category of cost and benefit relative to the base case. This involves estimating each category of cost and benefit above and beyond (or below and beyond) what would be expected to occur in the base case, ie, relative to the state of the world with the generator locational decision in question in it.

We also note that actually estimating each of these categories of costs and benefits would require significant market modelling, given the impact on the wider NEM that any generator locational decision has.

[5] Voluntary load curtailment is where customers (residential, commercial or industrial) agree to have their load curtailed, once electricity prices reach a predefined level. The price at which customers are willing to have their load curtailed represents the value of energy for these consumers.

4. Historical evidence of 'inefficient' locational decisions by generators in South Australia

As part of this assignment we consulted with a number of stakeholders regarding their perceptions of the historical efficiency of locational decisions by generators in South Australia. In particular, we were seeking their views on two specific examples we understand had been raised colloquially with the AEMC as part of the wider consideration of the OFA model as being potentially 'inefficient' locational decisions by wind generators in South Australia – namely:

1. Wind farms locating in the south east South Australia (SESA) region.
   - The Heywood interconnector has been upgraded several times, but the effect has been that new wind farms have located in the south east of South Australia, near the interconnector, to take advantage of the large capacity available.
   - The effect has been to diminish flows across the interconnector – with it being observed that the power transfer capacity of the Heywood interconnector is often constrained.
   - This has been suggested to be a problem since consumers are paying for interconnector upgrades predicated on the benefits of increased inter-regional flows, but these benefits may not eventuate due to inefficient locational decisions by generators.
2. Wind farms locating in the mid-north region of South Australia.
   - A number of wind farms have located around Northern and Playford B generators in the north of the state.
   - The AEMC understands that wind farms locating here have degraded these power stations' access, and that this may be a driver behind mothballing/retiring of plants in this area.
   - That is, wind generators locating in this area have created localised congestion, reducing access to the thermal generation.

We also sought the views of those we spoke with as to whether there were any other anecdotal pieces of evidence regarding potentially 'inefficient', or less than optimal, locational decisions by generators in South Australia. In addition, we have tried to elicit from stakeholders the extent that the observed outcomes would have occurred if instead there were more tractable locational pricing signals such as under the OFA model.

We note that in order to draw a considered conclusion as to whether or not these two sets of generator locational decisions can be considered to be inefficient or not, one would have to apply the framework we have developed in section 3 above. While the quantitative application of this framework is outside of the scope for this assignment, the results of the qualitative stakeholder discussions discussed below should serve as a useful input for the AEMC in deciding whether or not this larger quantitative exercise is warranted.

We would like to thank the stakeholders that were willing and able to be involved in this process. Specifically, the following parties: Infigen, GDF Suez, Alinta, AGL, ElectraNet, the Australian Energy Regulator (AER), the South Australian Department of State Development, EnergyAustralia and Origin.

4.1 Wind farms located in the SESA region

4.1.1 Impact on other parties

All parties we spoke with were of the view that the wind farms located in the SESA region do affect constraints that impact the limit of the Heywood interconnector.

By way of a high level overview, the transmission lines to Adelaide have a capacity of approximately 500MW, the transformers at Heywood have a current rating of 460MW (although this is being upgraded) and there are wind farms and gas turbines in the SESA region with approximately 450-500MW of installed capacity. Therefore, if the wind farms and gas turbines in SESA are generating, they are using all the transmission capacity in the region and there is limited capacity to import energy from Victoria to South Australia.

As a general proposition, an outcome where additional wind farm capacity degrades interconnector capacity is not necessarily an inefficient outcome. Wind generation represents a very low (or zero) cost source of generation, which displaces output from higher cost sources, including potentially imports of thermal generation from Victoria. However, we note that an inefficiency may arise where the degraded access results in higher cost thermal generation having to be dispatched in South Australia to meet demand than could have otherwise been imported from Victoria.

However, in discussions some stakeholder claimed that the decision of wind farms to locate on the 132kV network in SESA (as opposed to the 275kV network) has resulted in these wind farms having had a multiplicative effect on reducing the interconnector capacity. Specifically, these stakeholders claimed that every 1MW of wind farm capacity offsets *more* than 1MW of interconnector capacity (and it was stated to be more in the region of 1:2 – 1:3). It was suggested that the problematic wind farm connections in terms of this multiplicative effect on the interconnector were the connection of Lake Bonney 2 and Lake Bonney 3.

If it is the case that wind farms in the SESA region are offsetting more than 1MW of interconnector capacity for each MW of their own, then it is clearly a sub-optimal outcome and it is degrading the value of the interconnector. For example, in circumstances where demand is high in South Australia and there is not a lot of wind generation in South Australia generally but there is in the SESA region, the interconnector can only provide a fraction of the support it could if the SESA wind farms were not connected (or were connected but only offset 1MW of interconnector capacity for each 1MW of wind generation).

If these claims are correct, then it may be potentially problematic that these wind farms are receiving a high price in South Australia during some periods which is partially a result of their output constraining the interconnector. This may be evidence of an inefficiency associated with the locational decisions of these wind farms. However, this would need to be subject to a thorough assessment as outlined in section 3 above.[6]

Further, some stakeholders consider that schedule 5.2.5.12 of the NER may essentially establish that the addition of generation to any region should not adversely reduce the interconnector capability below the level that would apply if the generating system were not connected. If correct, these rules should have governed or precluded these wind farms connecting where they have (or changed the nature of this connection).

We also note that stakeholders expressed the view that the locational decisions of these SESA wind farms has been made worse (in terms of the effect on other parties) by the fact that demand has fallen, eg:

- Load has reduced in the SESA region (eg, Kimberley Clark’s pulp mill operations largely shutting down);
- The advent of medium size non-scheduled generation in the SESA region (eg, Kimberly Clark constructing a 21.75MW onsite cogeneration plant at its paper mill premises in the SESA region – largely taking its load off the grid); and
- Solar PV expansion in South Australia generally.

Since demand has decreased it means that the network has been more congested but not through the locational decisions of the wind farms. Put another way, the reduced ability of load in the SESA region and South Australia more broadly to ‘absorb’ the output of the wind farms has meant that the network in the

[6] We note that in speaking with stakeholders throughout the duration of this project, a number of other examples of generator locational decisions in the NEM having a greater than 1:1MW impact on interconnector flows have been raised, for example: Uranquinty, Kogan Creek, Basslink, Mortlake, Lower Tumut and Bogong.

SESA region and flows over the interconnector have become more greatly affected by the output of these wind farms.

In addition, in speaking with GDF Suez, we were informed that their Snuggery power station faced increasing constraints from wind farms in the SESA region, ie, the access of Snuggery has been degraded by these wind farms.[7] Snuggery is well-placed to sell market price cap contracts but they are currently limited in doing so because of these wind farms. GDF Suez informed us that they had actually considered relocating the Snuggery power station to avoid these constraints.

Overall, there was a broad consensus across those we met with that generators that have chosen to locate in the SESA region have done so primarily because of the superior wind resource and for the spot price that they get from the region (discussed further in the section below).

4.1.2 Drivers behind the locational decisions in question

The majority of parties we spoke with were of the view that the locational decisions of wind farms in the SESA region would not realistically be any different under an OFA arrangement, or otherwise. Put another way, the absence of such locational pricing signals was not a key driver of why wind farms chose to locate where they did in this region.

This point was made more generally by Castalia in the Snowy Hydro submission to the Transmission Framework Review where it was stated that there was no reason to believe that, had OFA been in place, a different set of generator locational decisions would have been made in the NEM since NEM-start.[8]

Stakeholders reiterated that the key locational factor for wind farm developers is the wind resource that they can access and the wind resources in the SESA region are some of the best in Australia. Wind farms earn the majority of their revenue from the large-scale generation certificate (LGC) price, which is independent from the spot price. Parties we spoke with were of the general view that the benefits of locating a wind farm in a region with a high expected capacity factor would likely drown out any marginal difference in locational prices from locating in a region with a lower capacity factor.

Many parties also noted that the marginal loss factors in the South Australian system already provide a strong locational signal. Specifically, marginal loss factors affect the revenue that wind farms earn from the spot market and we understand from our discussions that the marginal loss factors of wind farms in the mid-north region are significantly better than those in the SESA region. This relativity can be seen in Table 2 below, where all wind farms located in the mid-north region have a better marginal loss factor than those in the SESA region, with the exception of Snowtown.

[7] This was also noted in the Snowy Hydro submission to the Transmission Frameworks Review, see: Castalia, *Snowy Hydro Transmission Frameworks Review Submission*, 10 October 2012, p. 11.

[8] Castalia, *Snowy Hydro Transmission Frameworks Review Submission*, 10 October 2012, pp. 7-8.

Table 2: Marginal loss factors of South Australian wind farms, 2013-14

Station	Location	Loss factor
Lake Bonney 1	SESA	0.9426
Lake Bonney 2	SESA	0.9426
Lake Bonney 3	SESA	0.9426
North Brown Hill	Mid-north	0.9740
Clement Gap	Mid-north	0.9645
The Bluff	Mid-north	0.9740
Hallet Wind Farm	Mid-north	0.9794
Hallet 2 Wind Farm	Mid-north	0.9778
Snowtown	Mid-north	0.9272
Waterloo	Mid-north	0.9783

Source: AEMO, List of Regional Boundaries and Marginal Loss Factors for the 2013-14 Financial Year, 30 April 2013, pp. 43-44.

ElectraNet informed us that when the Lake Bonney wind farms connected in the SESA region, ElectraNet suggested to Infigen that, while more expensive for Infigen, connecting to the 275kV network would result in better access (rather than the 132kV network where they ultimately did connect). However, ElectraNet stated the view that the upfront capital costs of wind farms (including connection costs) are a primary deciding factor for wind developers, as opposed to possible future constraints that are typically thought of as a concern for the future. Overall, ElectraNet was of the view that no generators in South Australia (wind or otherwise) had made a locational decision to take advantage of network congestion.

As part of the Heywood RIT-T, Infigen was a proponent of a third transformer in SESA to remove some of the 132kV constraints. However, it was demonstrated as part of the RIT-T that it was not economic and that the option of a control scheme in the SESA region as well as a reconfiguration of the 132kV network was preferred.

It therefore seems that these anecdotal examples in the SESA region are evidence of potentially inefficiency on a broader level.

4.2 Wind farms located in the mid-north region

None of the parties we consulted with were of the view that the wind farms choosing to locate in the mid-north region of South Australia had resulted in any inefficiencies or, more specifically, degraded the access of Northern and Playford B power stations, which may have contributed to the mothballing/retiring of these plants.

In particular, those we spoke with were of the view that the decision to scale back operations at these power stations has been driven by a number of factors that are independent of the wind farms in the mid-north – namely:

- Coal supply concerns at Leigh Creek;
- The out-workings of the Renewable Energy Target reducing the spot price in South Australia (eg, the large number of wind farms locating in South Australia in general); and
- Declining demand in South Australia.

Specifically, Alinta (the operator of both Northern and Playford B) were of the view that the wind farms in the mid-north had not caused any adverse impact to these plants in terms of constraints.

Further, stakeholders were all of the view that there is plenty of network capacity in the mid-north region. ElectraNet noted that there currently exists sufficient network capacity in the mid-north to accommodate the latest National Transmission Network Development Plan expansion plan for this region of approximately 800MW. As background to this existing spare capacity, we understand that when the network was first built, it was built to accommodate four units at Northern power station and only two were ever built.

In addition, a number of stakeholders raised the point that even if the wind farms located in the mid-north region *did* degrade transmission access from Port Augusta (where Playford B and Northern are situated), it is unlikely to determinately impact Northern power station given their position in the contract market. When these wind farms are generating, the spot price in South Australia is likely to be low as a result and, even though Northern may be physically constrained off, they would not be removed from the contract market which is where they receive a significant amount of their total revenue.

The risk to Northern of any such constraints would be if they got constrained out of the market and the spot price in South Australia is very high, ie, they would get damaged in their contract positions.[9] However, we note that from discussions we had, this was not considered likely given the fact that when these wind farms are generating, the spot price in South Australia is likely to be low as a result of wind generation across the state being correlated.[10] Anecdotally, a number of parties told us that they were unable to find evidence of Northern being constrained and the spot price in South Australia being high.

Overall, the conditions that would lead to Northern being constrained are the same conditions that would result in spot prices being low in South Australia, ie, when the wind is blowing.

Interestingly, if the wind farms in the mid-north region were instead thermal generators the situation would be very different. Under these circumstances, it is a lot more likely that Northern power station would be constrained at times of high spot prices in South Australia and this would likely affect the profitability of Northern.

Similar to the decision of Alinta to scale back operations at its Port Augusta power stations, AGL informed us that the decision to retire the generating units at Torrens Island A in 2017 was in no way related to the locational decisions of wind farms in South Australia. This decision was instead made on the basis of issues relating the access of long-term gas supply and haulage for these units.

4.3 Wind farms located on the Eyre Peninsula

In addition to the two areas identified by the AEMC, many parties also raised the Eyre Peninsula as a potentially interesting case study.

It is reasonable to assume that the total revenue GDF Suez receives from its generators currently providing network support at Port Lincoln may have decreased as a result of the Mount Millar and Cathedral Rock wind farms choosing to locate on the Eyre Peninsula. Therefore, we would expect that the provision of this network support may become more expensive in the future because GDF Suez needs to recoup more of these generation costs from its network support contract with ElectraNet than it did prior to Mount Millar and Cathedral Rock beginning operations.

In such circumstances, while the price that the Port Lincoln generators receive in the spot market may be low as a result of wind farms locating across South Australia (and so not directly a result of the Mount Millar and Cathedral Rocks wind farms), the reduced volume that Port Lincoln generators can sell in the spot market is directly a result of these wind farms. This volume effect may therefore represent evidence of an inefficient impact on other parties directly attributable to the locational decisions of these wind farms.

[9] This point was raised more generally by the South Australian Government in their second submission to the TFR, see: Government of South Australia, *Submission to the Transmission Frameworks Review – Directions Paper*, 26 May 2011, p. 2.

[10] For example, there was the suggestion that Northern power station is more likely to be constrained in winter, when wind production is high and South Australian spot prices are consequently low.

4.4 Difference between congestion and oversupply

Many stakeholders thought it was useful to spell out the difference between the impacts on other parties as a result of congestion and the impact from a large upswing in wind generation in South Australia generally as a direct result of the LRET.

Specifically, while there are negative consequences for thermal power stations as a result of wind farms choosing to locate near them, from a whole-of-market perspective, these consequences typically represent benefits from competition and do not represent inherent inefficiencies. For example, the fact that the very high level of wind generation in South Australia in general has meant that a number of thermal generators have dramatically reduced operating regimes, does not necessarily reflect an inefficient outcome.

However, some parties expressed the view that there have been a number of times that, by virtue of there being so much wind generation being online in South Australia and the Heywood interconnector losing capacity, very little thermal generation has been online and South Australia has been very close to being load shed because thermal plants are operating at the bottom of their technical limitations.[11] For example, it was reiterated to us by a number of stakeholders that at the end of May 2014, Pelican Point was out of service when three Torrens Island units tripped and, if Northern had not recently came back online, South Australia would likely have had to have been load shed.

The South Australian Government also raised this point in its submissions to the TFR. Specifically, they raised the point that the ERET (now the LRET) requires significant investment in renewable generation that may result in substantial augmentations to the transmission network.[12]

It therefore seems that this may be evidence of inefficiency on a broader level, ie, associated with an oversupply of wind in South Australia relative to traditional generation that can pick up load quickly.

4.5 Locational decision of Mortlake power station in Victoria

A number of parties we spoke with raised the example of the Mortlake power station as having potentially inefficient consequences associated with its connection. It was put to us that often when Mortlake is generating, there are consequences for frequency control ancillary services (FCAS) in South Australia. It was suggested that in the 18 months since Mortlake was commissioned, there were approximately 6 market price cap events in the FCAS market in South Australia as a direct result of Mortlake running in the Victorian market. Therefore, the unintended consequences of connecting generation in Victoria on the ancillary services market in an adjoining market may reflect an inefficiency.

Notwithstanding these observations, parties suggested that a different outcome would not have arisen under OFA. In constructing Mortlake, Origin was primarily concerned with the proximity of the asset to a gas fuel resource, and any locational price signal provided by OFA would likely not have altered their decision to locate there.

4.6 Locational decisions of generators not registered for central dispatch

While somewhat outside of the remit for this report, a number of parties also raised with us the effect that the connection of a number of small generators by a single party can have on a region like South Australia. Specifically, it was expressed to us that Lumo Energy had connected a collection of diesel generators (totalling approximately 150MW) in South Australia that are not large enough individually to be centrally dispatched by AEMO.

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[11] It was expressed to us that Northern, Playford B, Torrens Island and Pelican Point are the only large thermal generators that can provide frequency control and, in these instances, are all running at very low levels.

[12] Government of South Australia, *Submission to the Transmission Frameworks Review – Directions Paper*, 26 May 2011, p. 2.

We were told that these generators sit largely offline but come online unpredictably whenever market price cap event are forecast and that, as a result of them being controlled by one party (ie, Lumo Energy), they cause severe difficulties in demand forecasting and price outcomes in South Australia.

We note that Lumo Energy is adhering to the NER but it may be a wider question of whether or not the NER is inadvertently resulting in adverse outcomes for participants in the NEM in examples like this.

5. Quantitative analysis

This section presents our indicative quantitative analysis. The purpose of this analysis is to investigate the claim made by many stakeholder we spoke with that there is a greater than 1:1MW relationship with these wind farms' output and the flows on the interconnector. Put simply, we are testing whether there is an *association* between the output of these wind farms and interconnector flows.

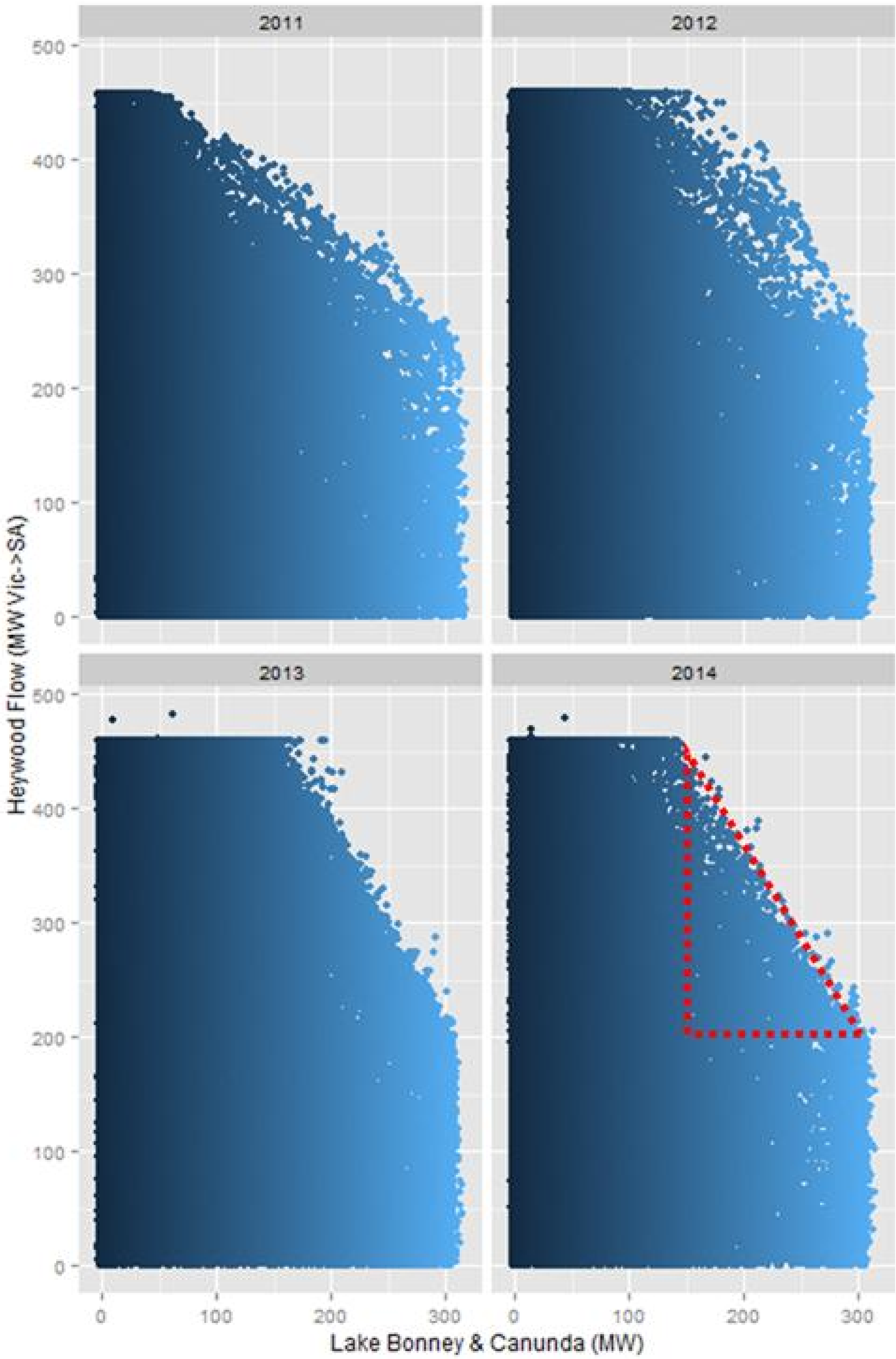
Importantly, this analysis does not assess whether there is any *causal connection* between the output of these wind farms and interconnector flows.

We have analysed data beginning in 2011, which is after the date that the last of these wind farms connected in the SESA region (Lake Bonney 3 connected in 2010). This allows us to test the claim that there has been a greater than 1:1MW relationship with these wind farms' output and the flows on the interconnector since they connected.

Our process has been to analyse the times that the Heywood interconnector was flowing from Victoria to South Australia and what the coincident output was from wind farms located in the south east region of South Australia during these times. Figure 3 below shows a scatter plot of times the interconnector was flowing from Victoria to South Australia for each of 2011, 2012, 2013 and 2014, against the coincident output of the Lake Bonney and Canunda wind farms located in the SESA region during these times.

What this analysis appears to confirm is the claim by many stakeholder we spoke with that there is a greater than 1:1MW association between these wind farms' output and the flows on the interconnector, from at least 2013-2014. For example, the superimposed red triangle suggests that for 2014 1MW extra from these wind farms coincided with a reduction of approximately 1.67MW of interconnector capacity (ie, 250MW/150MW). It also appears that this association did not exist in 2011 (the year following the connection of the last wind farm in the SESA region).

Figure 3: Heywood interconnector flows from Victoria to South Australia vs. output from Lake Bonney and Canunda wind farms, 2011 – 2014



Source: HoustonKemp analysis of AEMO MMS dispatch data.

6. Conclusion

In summary, the AEMC has asked us to investigate whether or not there is historical evidence of inefficient locational decisions being made by two sets of generators in South Australia – namely:

1. Wind farms locating in the SESA region of South Australia; and
2. Wind farms locating in the mid-north region of South Australia.

In order to draw a robust conclusion as to whether or not these sets of generator locational decisions can be considered to be inefficient, one would have to apply the framework we have developed in section 3 above. While the quantitative application of this framework is outside of the scope for this report, we have consulted widely with stakeholders on these two propositions as well as hearing the views of those we spoke with as to whether there were any other anecdotal pieces of evidence regarding potentially 'inefficient', or less than optimal, locational decisions by generators in South Australia.

Our primary findings coming out of this consultation process and our quantitative analysis are as follows:

- Wind farms in the SESA region of South Australia do affect the interconnector flows but that this generally is not an indication of inefficiency to the extent that wind, as a very low or zero marginal cost generator, is offsetting more expensive generation from the rest of the NEM;
- There appears to be an association between the output of Lake Bonney and Canunda wind farms and flows on the interconnector since at least 2013-14 (ie, 1MW extra from these wind farms coincided with a reduction of more than 1MW of interconnector flows):
  - If this relationship is proven to be causal, this may be evidence of a sub-optimal outcome, eg, in circumstances where demand is high in South Australia and there is not a lot of wind generation in South Australia generally but there is in the SESA region, the interconnector can only provide a fraction of the support it could if the SESA wind farms were not connected. Importantly though, our indicative analysis is not capable of drawing conclusions relating to causality.
  - There are provisions in the NER that some stakeholders consider aim to prevent this outcome (ie, schedule 5.2.5.12), although there were concerns about how these provisions had been applied;
- None of the parties we consulted with (including Alinta) were of the view that the wind farms choosing to locate in the mid-north region of South Australia had resulted in any inefficiencies or degraded the access of Northern and Playford B power stations, which may have contributed to the mothballing/retiring of these plants.
  - These operational decisions were driven by factors outside of the locational decision of these wind farms (eg, coal supply issues at Leigh Creek, lower spot prices in South Australia generally as an outworking of the LRET and declining demand in South Australia);
  - There exists significant excess capacity in the network connecting the Northern and Playford B power stations to the rest of the NEM southwards;
  - Even if the wind farms located in the mid-north region *did* degrade access for these power stations, it is unlikely to determinately impact Northern power station given their position in the contract market. When these wind farms are generating, the spot price in South Australia is likely to be low as a result and, even though Northern may be physically constrained off, they would not be removed from the contract market which is where they receive a significant amount of their total revenue.

Overall, stakeholders were of the view that concerns in relation to the locational decisions of wind farms in South Australia are not necessarily due to a locational inefficiency of particular sets of generators in South Australia but rather the result of the large amount of wind farms choosing to locate in South Australia (in response to the LRET) because of the superior wind resource.

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