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markets

South Australia's wholesale electricity market:
what really happened in July 2016?

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Summary

The South Australian wholesale electricity market had a volume-weighted average price of \$433/MWh for the first two weeks of July. By way of comparison, the volume-weighted average wholesale price in South Australia for the last eight calendar years has been \$64/MWh. Extraordinarily high prices (greater than \$2,000 per MWh) occurred in July for numerous half-hourly settlement periods but particularly on July 7th and sporadically also for various half-hours on the 6th and 8th and again roughly a week later.

In response to these events we have been asked to analyse and report on what occurred in the wholesale market in July 2016. Extraordinarily high wholesale prices in the spot market are not unusual in South Australia. These extraordinary prices do occur sporadically and often when demand is far below annual peaks. However it is unusual to see so many intervals of extreme prices in winter as has occurred this July when demand has been barely higher than average annual demand.

We think the explanation for these extreme price outcomes is clear. There was no genuine capacity shortfall at the time of the extreme prices, the installed (and not mothballed) generation capacity far exceeded the demand. AEMO had forecast extremely high prices 12 hours in advance, and if they had wanted to, South Australia's gas and diesel generators could have prepared their plant to produce. In other words, despite the absence of wind generation and the limitations in interconnector capacity, there was still plenty of generation capacity that was available, or could reasonably have been expected to be available, at the time that these extreme prices occurred. Had this capacity been made available to the market at more reasonable prices, even prices far above production costs, those extreme prices would not have occurred.

In any market, producers' motivation to produce will depend on market prices, their production costs, and their contractual commitments. In order to meet the demands of their customers plus their contractual commitments, producers have an incentive to produce as long as it is cheaper for them to do so, than to buy from the market (and then by on-selling to their customers, satisfy their contractual commitments). In deciding whether to produce in excess of their contractual commitments, producers

will be mindful of the extent to which withholding some part of their production from the market might increase market prices and if so whether the benefit they gain from such higher prices more than offsets their lower production.

In a market characterised by high levels of rivalry, participants can not expect to influence market prices through their own production decisions - they “take” rather than “make” market prices. Indeed, this is often adopted as the working definition of a competitive market. In an actively competitive market, producers can be expected to make their plant available to the market at prices just above their avoidable production costs. Or if there is a genuine scarcity in the market, at some higher price that reflects the value of that scarcity to consumers.

As long as the market is well supplied (that is there is no genuine scarcity) the resulting rivalry can be expected to result in market prices close to the avoidable costs of the highest cost (marginal) producer. In the case of the South Australian market on the 7th of July, the avoidable production costs of the most expensive producer would surely not have exceeded \$300 per MW. But the actual prices in the market (above \$2,000 per MWh for most settlement periods and up to \$8,800 per MWh for some) are many multiples of the avoidable production cost of the most expensive dispatched generator. The existence of a such a large gap between market prices and the highest plausible estimate of the marginal cost of production, at a time when there was no genuine scarcity, is strongly indicative of inadequate market rivalry. The generators could “make” the prices in the market, rather than “take” them from the market. Producers might be expected to have gained from this in various ways including:

- through higher net spot market income (the effect of much higher prices outweighing the effect of lower volumes) for uncontracted production;
- the ability to undermine the competitive position of uncontracted retailers in the short term;
- the ability to “punish” end users who might have decided to buy directly from the spot market rather than through retailers; and
- the ability to drive up price expectations in contract markets.

For the 8.5 hours on 7 July, the South Australian spot market paid the dispatched generators \$46m. Had spot prices not exceeded the highest plausible clearing price

assuming vigorous rivalry (we assume \$300 per MWh based on the production costs of the marginal unit) the spot market would have paid the generators \$5m. It is impossible to know who gained from this difference since it will depend on the confidential contract positions of the various generators (and how much of their load was accounted for through fixed tariffs). But we can be sure that events like this explain the significant difference in demand-weighted average spot prices in South Australia compared to other NEM regions. This is ultimately reflected in the prices that end users pay.

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1 Introduction

The South Australian wholesale electricity market had a volume-weighted average price of \$433/MWh for the first two weeks of July. By way of comparison, the volume-weighted average wholesale price in South Australia for the last eight calendar years has been \$64/MWh. Extraordinarily high prices (greater than \$2,000 per MWh) occurred in July for numerous half-hourly settlement periods but particularly on July 7th and sporadically also for various half-hours on the 6th and 8th and again roughly a week later.

Journalists in print media commented on this, leading to an animated debate on the source of the price spikes. High wholesale prices have been variously attributed to maintenance on the interconnector to Victoria, to South Australia's reliance on wind farms, to excessive gas prices, to inadequate competition in gas and wholesale electricity markets and to the exposure of large end users who had chosen to source their electricity directly from the spot market and ended up on the wrong side of spot market trades.

In response to these events we have been asked to analyse and report what occurred in the wholesale market in July 2016.

Extraordinarily high wholesale prices in the spot market are not unusual in South Australia. These extraordinary prices do occur sporadically and often when demand is far below annual peaks. However our analysis of the historic data shows that extreme prices are most likely to occur in the period from late January to mid-February when schools and industry recommence after the summer break, at the same time that very high temperatures stimulate demand for air-conditioning. It is unusual to see so many intervals of extreme prices in winter as has occurred this July when demand has been barely higher than average annual demand.

In summary, our view is that events of 7 July are not reasonably attributable either to becalmed weather or diminished interconnector capacity. We attribute the high prices to South Australia's gas and diesel generators' decision to only make their capacity available to the market at very high prices (typically greater than \$5000 per MWh). The

extreme prices demonstrate the ability of those generators to achieve very high prices by contriving scarcity. This is not a new phenomenon and neither is it unique to South Australia, though the history shows it has been more common and severe in South Australia than in other regions of the National Electricity Market (NEM).

To provide context and understanding to the events of July, this report begins with a description of the wholesale market and of the historic outcomes in South Australia. It then analyses the events of 7 July. Finally, it concludes.

2 Description of the wholesale market

South Australia is one of five regions of the National Electricity Market (NEM). The NEM is a mandatory (for generators above 30 MW) centrally settled market in which auctions are conducted every five minutes for supply at the regional reference node. In South Australia this is in Adelaide. Prices are settled half-hourly as the simple average of the prices in the six five-minute auctions in that half hour. There is a cap on prices of \$14,000 per MWh and a floor of -\$1,000 per MWh in any one settlement period and a rolling cap which guards against accumulation of high prices (above \$500 per MWh) over a rolling week. Markets also exist for the provision of services that help to ensure the security of the power system and its operation within tight frequency bands. The value of trades in these markets is usually comparatively inconsequential.

Market participants can swap the half-hourly spot prices for prices that are fixed for various periods from months to years, by entering into futures contracts traded through the Sydney Futures Exchange or by entering into forward contracts which are negotiated bilaterally or through brokers. Information on bilateral and brokerage trades is not publicly available. The information on the volume and traded prices of futures contracts is available publicly. It shows that there is negligible trade of futures contracts for supply in South Australia.

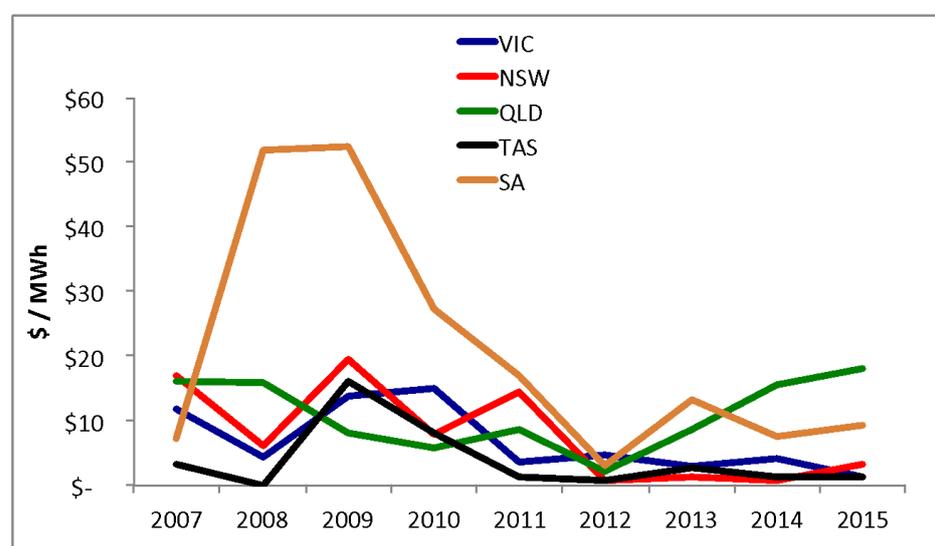
The NEM has many unusual features including that it remunerates only the electricity that is produced and its mandatory single price nature (similar markets exist in New Zealand and Texas but by far the dominant model internationally is a voluntary balancing market¹). The NEM also runs 5-minute auctions and is a regional, rather than locational market. As far we are know the 5-minute auction is shorter than the trading

¹ A voluntary balancing market is a market in which market participants (buyers and sellers) are free to choice to participate in order to balance any difference between their contracted production/consumption and their actual production/consumption. An energy-only market is a market which compensates only the production of electricity. A capacity and energy market compensates for the production of energy and for making capacity available to produce, even if it is not called on to produce.

interval adopted in any other mandatory wholesale market. A philosophy in the design of the NEM is the minimisation of administrative intervention and an attempt to ensure prices reflect the balance of demand and supply as accurately as possible. Economists recognise the relative “purity” of energy markets such as the NEM, but acknowledge that a disadvantage of this approach is that it provides very powerful incentives for the exercise of market power since the reward for that is extremely high prices.

Extremely high prices in a few settlement periods have significantly affected average annual electricity prices in South Australia. Figure 1 shows the amount by which average prices (\$/MWh) increased, over the calendar year, as a result of the prices in the highest 72 half-hours during each year². So for example in South Australia in 2008 and 2009, the demand-weighted average wholesale prices in South Australia were a little over \$50 per MWh higher than they would otherwise have been as a result of the extreme prices in 72 half hours or around 0.41% of the year. The chart shows that the effect in South Australia was particularly pronounced from 2008 to 2010 and again in 2013.

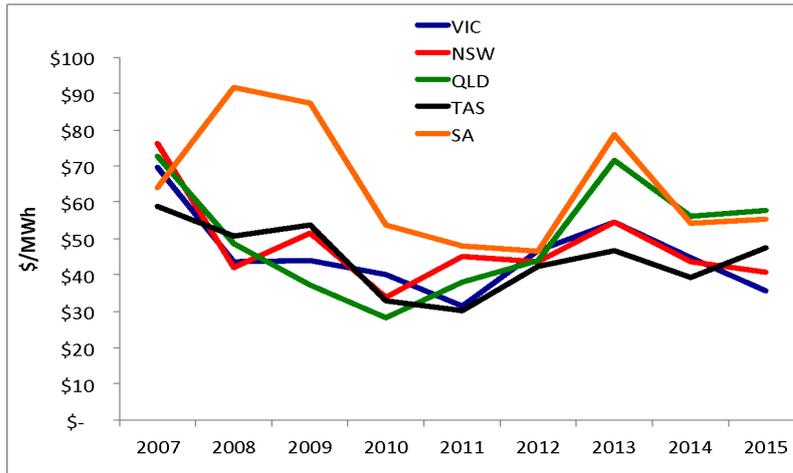
Figure 1. Impact on average annual wholesale prices of the highest 72 half-hourly prices in each year



² The choice of 72 is arbitrary. The point is that the prices in some small part of each year – in this case 0.41% of the year, have a large impact on average annual prices.

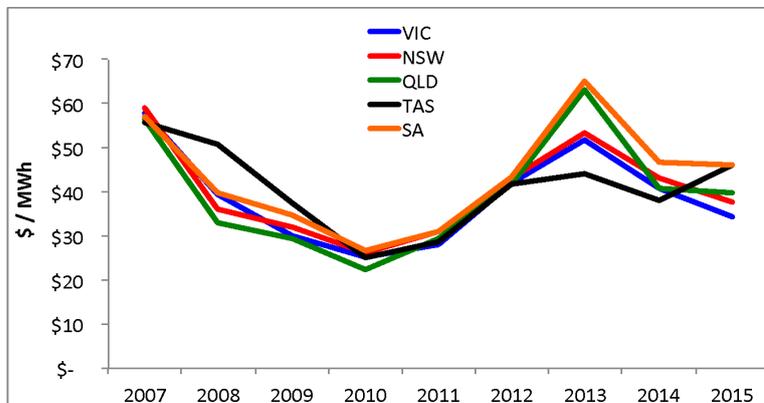
To put this effect in the context of the demand-weighted average annual prices in the NEM, Figure 2 below shows these demand-weighted average prices. The effect of the extreme prices in 2008 to 2010 and again in 2013 is evident in this chart. Comparing Figure 1 and Figure 2 it is clear, for example, that average annual prices in 2008 and 2009 more than doubled as a result of the extreme price in just 72 half hours in those years.

Figure 2. Demand weighted average annual wholesale prices



Finally, Figure 3 below shows the average annual prices in the NEM regions, excluding the 72 highest priced half hours. This shows that other than in 2013, demand-weighted prices in South Australia would have been comparable to those in the other regions of the NEM.

Figure 3. Demand-weighted average annual wholesale prices excluding the 72 highest priced half-hourly settlement periods



Mountain (2012) examined the dispatch of generators in South Australia during these extreme settlement periods from 2008 to 2012. His analysis of the very high priced settlement periods in South Australia in the period from 2008 to 2012 showed that the cause was not scarce supply. When extreme prices occurred, typically (but not always) at times of very high demand, there were still substantial amounts of generating capacity that could have been made available to the market, but was not. For example, in 2008 for the half-hourly settlement periods when the South Australian spot prices were at the Market Price Cap of \$10,000 per MWh, there was on average 667 MW of generating capacity at the Torrens Island Power Station that was not producing electricity. Similar outcomes occurred in 2009 and 2010. In 2011 however, the situation changed. This time the Torrens Island Power Station generating units were producing at or near their full capacity, while the brown coal generators (Playford and Northern) had substantial amounts of spare capacity available (on average 423 MW) when the market price was at or near the Market Price Cap.

It is important to be clear that for almost all small customers (households and small businesses) prices are determined in retail electricity offers in which prices are either fixed for a period of time, or vary but not more than once every few months (typically longer). Outcomes in half-hourly spot markets do affect retail prices but much more gradually. Their effect is nonetheless important to small customers not just in respect of the wholesale costs to retailers, but also in respect of the relative competitive position of different retailers. Larger customers typically contract for electricity in contracts of two to three year's duration often with prices that are largely fixed or capped. Wholesale prices affect the electricity bills to larger power users more than for smaller since the wholesale price makes up a larger proportion of their total electricity bill.

3 Analysis of outcomes in South Australia on 7 July 2016

There were 36 half-hours during the first three weeks of July when wholesale prices exceeded \$2,000 per MWh. On July 7th these price spikes occurred successively for 16 half-hours (with the exception of one half-hour) between 1.30pm to 10pm. The analysis here focuses specifically on that time period.

During that period the output from the circa 1,200 MW of wind farm capacity in SA averaged 9 MW and dipped to 1.33 MW in one settlement period. For most of the period, the MurrayLink Direct Current (DC) interconnector was flowing westward from Victoria into South Australia averaging 126 MW. But the main Heywood interconnector had average imports to South Australia of just 9 MW and for some settlement periods was actually flowing eastward from South Australia to Victoria despite much lower prices in Victoria. We understand that the reduction in the Heywood interconnector's capacity was due to work being carried out as part of its upgrade. The average simultaneous peak demand on the South Australian power system over this period was 1,863 MW. This is not much higher than the average annual demand of around 1,500 MW and substantially below the simultaneous annual peak demands of around 3,000 MW. However since interconnector flows into South Australia were limited somewhat below their normal capacity, and since on July 7th wind farm capacity was generally negligible, this left a larger than average amount of generation to be met by South Australia's gas turbine and diesel reciprocating engine capacity.

It would seem that those commentators who pointed the finger at SA's becalmed wind farms had noticed the correlation of low wind generation with very high prices on the 7th of July and made a causal link between the two, i.e. they assumed that spot prices were high because wind farms were becalmed.³

³ It is difficult to know why these commentators have so obviously confused correlation with causation. Three possibilities arise. Firstly it might reflect an aversion to renewable technology perhaps because it is relatively innovative or because it is motivated in part by policy to reduce greenhouse gas emissions,

Our assessment of the data does show that wind farm production is negatively correlated with spot prices in South Australia i.e. that spot prices tend to be higher when wind production is lower and vice versa. However this is not a significantly negative correlation. Over the period from 1 to 24 July 2016 - which encompasses all the very high priced half-hours in July - the correlation of wind production with spot prices was 15%. Looking at period from 2006 to 2012, Mountain (2013) found a similar negative correlation between wind generation and extreme prices.

Regardless of the mild negative correlation, it is important not to confuse correlation with causation. To understand causation it is necessary to examine what was happening in the market when the prices were high and wind production low. The rest of this section conducts just such an examination, and finds that it is not reasonable to blame the absence of wind generation for the higher prices in July 2016.

Figure 4 below, copied from the Australian Energy Regulator's (AER) 3-9 July pricing report, shows the actual prices, demand and generation availability and compares this to Australian Energy Market Operator's (AEMO) published predictions of these 12 hours before actual and 4 hours before actual.

which policy those commentators might not agree with. A second possibility might be an unvoiced preference for "base load" capacity. That is, controllable capacity whose optimum economic operation is consistent output for long periods of time. Renewable generation, except biomass and hydro, depend on the availability of renewable resources. "Base load" generation can present additional, often hidden, costs associated with its operational inflexibility. For example to ensure sufficient load to keep the coal fired boilers above their minimum stable generation levels during load demand periods at night has justified, in part, the development of pumped storage generation and oversized and poorly insulated resistive load off-peak water heaters in millions of Australian homes. The promotion of some energy intensive industries in which Australia has had little comparative advantage and which relied on enduring protection to develop and then operate played a similar role at times in the development of major coal generation plant, Loy Yang A being an example of this. A third possibility might be reference to the disruptive influence of large amounts of renewable capacity that have negligible marginal costs. If such capacity is at the margin, spot prices will often be negative or close to zero. This leaves ever shorter periods of time in which fossil fuel plant will be dispatched and able to generate income to recover operating costs and make a contribution to fixed costs and profits.

Figure 4. Actual versus forecast prices, demand and generation availability on 7 July 2016

Time	Price (\$/MWh)			Demand (MW)			Availability (MW)		
	Actual	4 hr forecast	12 hr forecast	Actual	4 hr forecast	12 hr forecast	Actual	4 hr forecast	12 hr forecast
1.30 pm	2089.86	10 586.13	10 586.12	1565	1594	1567	2080	2084	2077
2 pm	1963.94	10 586.13	10 586.12	1605	1594	1587	2085	2082	2076
2.30 pm	2450.46	410.53	10 586.12	1632	1561	1585	2086	2099	2092
3 pm	1940.90	300.10	10 586.12	1634	1532	1589	2086	2100	2092
4 pm	2145.90	495.10	10 586.13	1586	1579	1632	2131	2143	2140
4.30 pm	1901.42	13 329.90	10 586.12	1699	1642	1684	2208	2209	2211
5 pm	2036.19	13 329.90	13 481.81	1768	1715	1747	2209	2204	2212
5.30 pm	1960.53	13 329.90	10 586.12	1871	1835	1853	2209	2204	2214
6 pm	2086.58	13 481.81	13 999.99	2008	1987	1995	2209	2204	2215
6.30 pm	2375.11	14 000.00	14 000.00	2151	2151	2144	2208	2208	2218
7 pm	2481.97	14 000.00	14 000.00	2159	2226	2206	2199	2214	2219
7.30 pm	8897.80	14 000.00	14 000.00	2140	2233	2206	2221	2215	2225
8 pm	3604.79	14 000.00	14 000.00	2110	2204	2177	2217	2215	2230
8.30 pm	1984.87	13 329.90	14 000.00	2089	2127	2151	2214	2215	2233
9 pm	3624.04	13 329.90	13 999.99	2042	2087	2106	2218	2220	2237
9.30 pm	3580.14	13 329.90	13 999.99	1998	2057	2064	2216	2227	2238
10 pm	1914.91	13 329.90	14 000.00	1909	1974	1985	2217	2237	2243

Source: AER, Electricity Report 3 to 9 July

The figure shows that AEMO anticipated that extremely high prices were possible on the basis of their forecast of both generation availability and demand. As it had turned out these generation availability and demand predictions were remarkably accurate in almost all half-hourly settlements. With these forecasts, the gas and diesel generators in South Australia had been given a clear signal that demand and generation availability was such that very high prices could be expected. Yet, they did not respond to that information by making more of their production available to the market. Had they done so, while prices would have been lower, they might still have expected that they could amply cover their production costs thus making a sizeable contribution to their profits. In particular, our analysis of the installed capacity, and the peak and average production from gas and diesel generators, by operator over the relevant 7 July period shows that Origin alone was operating its gas generation close to capacity over this

period. All the other generators were operating their plant well below capacity. This is shown in Table 1 below.

Table 1. Installed capacity, peak and average output on 7 July 2016 from 13h30 to 22h00

	Snowy Hydro	Engie	Origin	AGL	EnergyAustralia
Installed capacity (MW)	178	844	484	1,280	180
Peak output (MW)	99	220	494	1,010	173
Average output (MW)	69	188	469	872	132

Obviously not all the operators would have been able to produce at their full capacity since this would have far exceeded the demand. The criticism lies not in their failure to produce at their capacity, but rather in the observation that the installed (and not mothballed) generation capacity far exceeded the demand. Considering especially that AEMO had provided these generators with the likely prices, it is reasonable to expect that the vast bulk of this capacity (in total 2,966 MW) could have been prepared and able to produce over this period. In other words, despite the absence of wind generation and the limitations in interconnector capacity, there was still plenty of generation capacity that was available, or could reasonably have been expected to be available, at the time that these extreme prices occurred. Had this capacity been made available to the market at more reasonable prices, even prices far above production costs, those extreme prices would not have occurred.

With the high prices that AEMO had signalled, 12 hours before the event, the operators of the gas plant would have had powerful incentives to produce enough electricity from plant that they controlled, to meet the demand of their own customers and to fulfil any hedge contracts they had entered into. If they did not produce enough electricity to meet these commitments, they would have had to procure shortfalls at the spot price. We surmise that the average output of each of the companies over these extreme price periods reflects this.

In any market producers' motivation to produce will depend on market prices, their production costs, and their contractual commitments. In order to meet the demands of their customers plus their contractual commitments, producers have an incentive to produce as long as it is cheaper for them to do so than to buy from the market (and by on-selling to their customers, satisfy their contractual commitments). In deciding whether to produce in excess of their contractual commitments, producers will be

mindful of the extent to which withholding some part of their production from the market might increase market prices and if so whether the benefit they gain from such higher prices more than offsets their lower production. In a market characterised by high levels of rivalry, participants can not expect to influence market prices through their own production decisions - they “take” the market prices rather than “make” the prices from the market. Indeed, this is often adopted as the working definition of a competitive market. In an actively competitive market, producers can be expected to make their plant available to the market at prices just above their avoidable production costs. Or or if there is a genuine scarcity in the market at some higher price that reflects the value of that scarcity to consumers. As long as the market is well supplied (that is there is no genuine scarcity) the resulting rivalry can be expected to result in market prices close to the avoidable costs of the highest cost (marginal) producer. In the case of the South Australian market on the 7th of July, the avoidable production costs of the most expensive producer would surely not have exceeded \$300 per MW. But the actual prices in the market (above \$2,000 per MWh for most settlement periods and up to \$8,800 per MWh for some) are many multiples of the avoidable production cost of the most expensive dispatched generator. The existence of a such a large gap between market prices and the highest plausible estimate of the marginal cost of production, at a time when there was no genuine scarcity, is strongly indicative of inadequate market rivalry. The generators could “make” the prices in the market, rather than “take” them from the market. Producers might be expected to have gained from this in various ways including:

- through higher net spot market income (the effect of much higher prices outweighing the effect of lower volumes) for uncontracted production;
- the ability to undermine the competitive position of uncontracted retailers in the short term;
- the ability to punish end users who might have decided to buy directly from the spot market rather than through retailers; and
- the ability to drive up price expectations in contract markets.

For the 8.5 hours on 7 July, the South Australian spot market paid the dispatched generators \$46m. Had spot prices not exceeded the highest plausible clearing price (we assume \$300 per MWh based on the production costs of the marginal unit) the spot market would have paid the generators \$5m. It is impossible to know who gained from

this difference since it will depend on the confidential contract positions of the various generators (and how much of their load was accounted for through fixed tariffs). But we can be sure, as set out in the previous section, that this difference and similar repeated events explain the significant difference in demand-weighted average prices in South Australia compared to other NEM regions. This is ultimately reflected in the prices that end users pay.

Finally, for completeness, we comment on the impact of higher gas prices on wholesale electricity prices in South Australia. The liquefaction and export of gas has created a large demand for Australia's conventional gas reserves and production. The effect of this on domestic gas prices is not known with certainty since gas contracts are confidential. The price of gas in visible short term balancing markets is not indicative of the prices on large gas supply contracts since such balancing markets trade smaller volumes over much shorter periods. We observe from discussion with market participants and the trade press that prices on large multi-year gas contracts have increased from around \$3 per GJ in the past to somewhere in the band from \$6 per GJ to \$9 per GJ.

This obviously increases the price of electricity produced from gas-fired generators in South Australia.⁴ It is reasonable to imagine that such higher gas prices will require higher electricity prices at least in respect of the generation produced from gas-fired equipment. However, it is important to be clear that this is not relevant in explaining the price outcomes in July during which extreme wholesale prices were many multiples of the cost of electricity production even at the contemporary, much higher, gas prices.

⁴ We estimate that at contemporary gas prices, the production cost from South Australia's gas thermal (Torrens Island) or open cycle turbine capacity (Dry Creek, Hallett, Ladbroke Grove, Mintaro & Quarantine) might be around \$100 per MWh, and from combined cycle gas capacity (Osborne and Pelican Point) might be around \$70 per MWh. Diesel capacity at Port Lincoln and Snuggery might have a production cost of around \$300 per MWh.

4 Conclusions

On the basis of this evidence and reasoning we suggest that it is not plausible to conclude that a causal relationship exists between becalmed wind farms and the extraordinary prices in July 2016. Rather the main reason for the extraordinary prices is inadequate rivalry amongst the operators of South Australia's gas and diesel generating plant. The fact that these generators did not compete to get their plant dispatched when prices were many multiples of their production costs suggests that these generators stood to gain more by withholding capacity from the market or, equivalently, making it available only at extremely high prices, than by competing vigorously to offer their production to the market.

Finally, there is a nascent debate on the appropriateness of an energy-only market in the situation where fossil fuel generation, particularly inflexible fossil fuel generation, will have an ever-declining share of the market. This is the situation in Britain and in many continental European countries. Interesting though this is, this is irrelevant in understanding clearly what has occurred in South Australia in July 2016.

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