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The exercise of market power in Australia's National Electricity Market following the closure of the Hazelwood Power Station

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VEPC Working Paper 1901
March 2019

Abstract

The National Electricity Market, a wholesale market covering Australia's southern and eastern states, commenced operation in 1998. Though the market has long been considered a successful part of Australia's energy market reforms, econometric analysis finds that coal generation closure in 2017 delivered an unexpected price shock in wholesale markets. Further analysis finds that average prices received by the coal-fired generators when coal generators set the clearing prices, more than doubled in the year after closure compared to the previous year. These increased spot market revenues collected by the coal generators by $3.47 billion from what they would have been if generator bids before closure had prevailed. We propose a model of oligopolistic competition to explain the price outcomes. After examining the impact of higher coal prices and possible exogenous coal supply constraints, we conclude that the change in generator bids in the spot market is consistent with the optimal markup rule in our model. We find that the entity that exercised the market power was able to increase its wholesale market profits by 60% and was able to substantially pass on wholesale price increases in the prices they charged their customers. We suggest this is typical of outcomes across the market, and thus the exercise of market power has had a large impact on consumers and producers, economic efficiency and the environment. The conclusions raise concerns about supply-side market concentration, and also about the design, operation and oversight of the wholesale market. This merits serious consideration not least in the context of future coal generation closure.

Keywords: Market power, coal generation closure, oligopoly

JEL Classification: D22, D43, L11, L13

DOI: 10.26196/SFEK-0X91

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1 Introduction

This paper examines the wholesale (spot) and contract prices in the National Electricity Market (NEM) before and after the Hazelwood Power Station closed in April 2017, and seeks to determine whether price changes reflect the exercise of market power.

The NEM is a centrally-settled uniform price mandatory energy-only wholesale market that determines the production of almost all large-scale electricity generation in Australia's south and eastern states. It commenced operation in 1998 and has long been considered a successful part of Australia's energy market reforms.

The Hazelwood Power Station was a 1600 MW brown coal-fired generator which closed on 31 March 2017. In its last full year of operation, it produced 23% of the centrally dispatched electrical energy produced in Victoria or 5% across the NEM. Hazelwood, unusual compared to other coal closures, was highly used in its final year of operation.[1]

The large electricity markets in the NEM, covering the states of Victoria, New South Wales and Queensland are moderately to strongly interconnected, and there remains substantial spare coal generation production capacity in the NEM, particularly in New South Wales. However, the weighted average price in the NEM increased from $52/MWh to $96/MWh comparing the calendar years before and after the Hazelwood Power Station closed.

To further understand the price change after Hazelwood's closure in the context of a growth of renewable generation, changes in gas prices, coal generation closure and changes in demand in the NEM, we developed an econometric model, discussed in detail in (Mountain and Percy, 2018), and applied it to all NEM regions. The findings showed that the wholesale price increase caused by the loss in available capacity due to Hazelwood closure was largest in Victoria, followed by New South Wales, South Australia and Queensland.

[1] 5,100 MW of coal-fired generation in the NEM has closed over the last 6 years, but much of this was rarely used before Hazelwood closed.

In order to understand the extent to which the market impacts after Hazelwood's closure might be associated with the exercise of market power, in this paper we assess the extent to which the observed outcomes when coal-fired generators set market prices are consistent with a model of oligopolistic competition. We focus on the coal generation share of the market in order to exclude the impact on prices when production from other (more expensive) fuel sources were at the margin.

By examining the prices received by, and production of, the various coal generators, we can test whether these are consistent with the predictions of the optimum mark-up rule of our oligopoly model, based on Woerman (2018). We also test whether changes in coal prices and coal constraints explain outcomes. We conclude that coal prices cannot explain outcomes and that exogenous, unpriced, coal supply constraints affected generator bids for all but the dominant market participant, whose generator bids and production are consistent with the predictions of our model.

We then quantify the impact of this exercise of market power to producers, consumers, the environment and economic efficiency. The impacts are large and raise obvious concerns about concentrated supply, and also about the design, operation and oversight of the wholesale market.

We contribute to the economic literature through the application of sophisticated empirical and data analysis techniques in the application of a model of oligopolistic competition. As far as we know, this is the first academic paper focussed on the exercise of market power in the NEM in general, and certainly the first that isolates the analysis of the competitiveness of the coal-generation market.

The paper is set out as follows. Section 2 describes the market and industry, measures its concentration and reviews regulatory studies of the exercise of market power following Hazelwood's closure. Section 3 sets out the analysis of market power, followed by Section 4 that draws out the implications. Section 5 presents the conclusions.

2 Background

2.1 The National Electricity Market

The National Electricity Market (NEM) describes the interconnected power system and wholesale market that covers the large-scale production and supply of electricity in five separate markets aligned with the state boundaries of Queensland, New South Wales, Victoria, South Australia and Tasmania. The Australian Energy Market Operator (AEMO) operates the power system and market according to the provisions of the National Electricity Law and National Electricity Rules which are administered by the Australian Energy Markets Commission (AEMC).

The NEM covers 54 GW of grid-connected generation capacity that uses coal, gas, wind, hydro and the sun as primary energy sources, which in total produced about 200 TWh of electrical energy in 2017. The total value of electricity transacted through the wholesale market in the 2017 financial year (to 30 June) was $16.6 billion.

The wholesale "spot" market is a 5-minute energy-only market where generators bid their capacity in ten price/quantity bands. Bids are stacked in price order for each 5-minute interval, with the uniform market clearing price being the lowest bid that meets the forecast demand in each region subject to transmission capacity, power system and generation operational constraints.

Generators' price offers can be varied up to half an hour before the five-minute auction and quantities can be varied up to five minutes before. Prices are calculated at regional reference nodes corresponding to the location of the capital cities of each state. All generators in each region receive payment for their energy supplied after adjustment for loss factors, based on the regional Settlement Period prices calculated as the average of the six five-minute "Trading Period" prices in the region in which that generator is located. The NEM has a price cap of $14,200/MWh.

The five NEM regions are connected through six regional interconnectors. When interconnectors are unconstrained, regional prices converge, forming a single or multi-regional market. When interconnector constraints bind, the NEM regional markets separate and the market clearing price in each region is then determined by generation in each region.

Energy retailers, large consumers and generators agree futures and forward contracts to swap their exposure to the volatile half-hourly spot price for fixed prices.

As shown in Figure 1, while South Australia has undergone a significant transition to renewable energy in the last ten years (at the end of FY 2018 about 45% of energy came from wind and solar), the other NEM regions are lagging significantly with wind and solar production together accounting for 4% to 8% of production. The last coal-fired generator in South Australia, the Northern Power Station, which produced around a fifth as much as Hazelwood, closed in April 2016. The 1600 MW Hazelwood brown coal power station closed in Victoria at the end of March 2017, as seen by the reduced size of the brown bar in Victoria in FY 2018.

Victoria's coal-fired power stations burn brown (lignite) coal and New South Wales and Queensland coal generators burn black (bituminous) coal.

Figure 1. Electricity production by fuel type

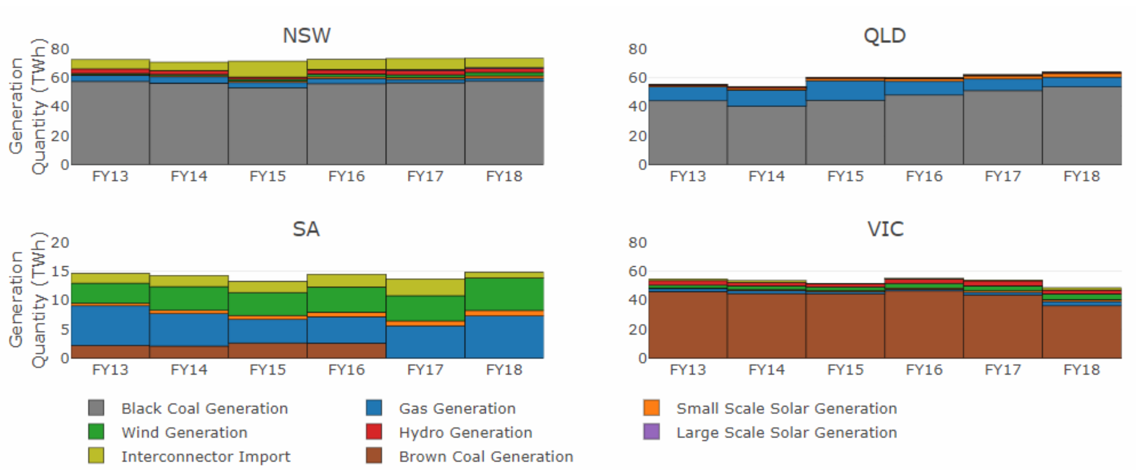


Table 1. Coal generation summary

	Station name	Participant	Name-plate capacity (MW)	Thermal efficiency (GJ/MWh)[2]	Coal energy content[3] (GJ/t)	Station utilisation[4] 2016/2017	
New South Wales – Black Coal	**Liddell**	AGL Macquarie Pty Ltd	2000	10.12	23	51%	47%
	Vales Point "B"	Delta Electricity	1320	9.7	23	68%	70%
	Eraring	Origin Energy Electricity Ltd	2921	9.51	23	51%	70%
	Bayswater	AGL Macquarie Pty Ltd	2640	9.43	23	72%	70%
	Mt Piper	Energy Australia Pty Ltd	1400	9.24	23	63%	60%
Queensland – Black Coal	**Gladstone**	CS Energy Ltd	1680	9.72	21	47%	55%
	Stanwell	Stanwell Corporation Ltd	1460	9.2	21	72%	71%
	Millmerran Power Plant	Millmerran Energy Trader Pty Ltd	852	9.17	21	92%	88%
	Tarong	Stanwell Corporation Ltd	1400	9.15	21	73%	76%
	Callide C	Callide Power Trading Pty Ltd	840	9.02	21	74%	76%
	Kogan Creek	CS Energy Ltd	744	8.83	21	73%	82%
	Tarong North	Stanwell Corporation Ltd	443	8.72	21	69%	81%
Victoria – Brown Coal	**Hazelwood**	Engie	1600	14.73	10.3	72%	77%
	Yallourn 'W'	Energy Australia Yallourn Pty Ltd	1480	13.96	10.3	88%	84%
	Loy Yang B	Alinta Energy Retail Sales Pty Ltd	1000	12.52	10.3	96%	101%
	Loy Yang A	AGL Loy Yang Marketing Pty Ltd	2210	12.04	10.3	81%	82%

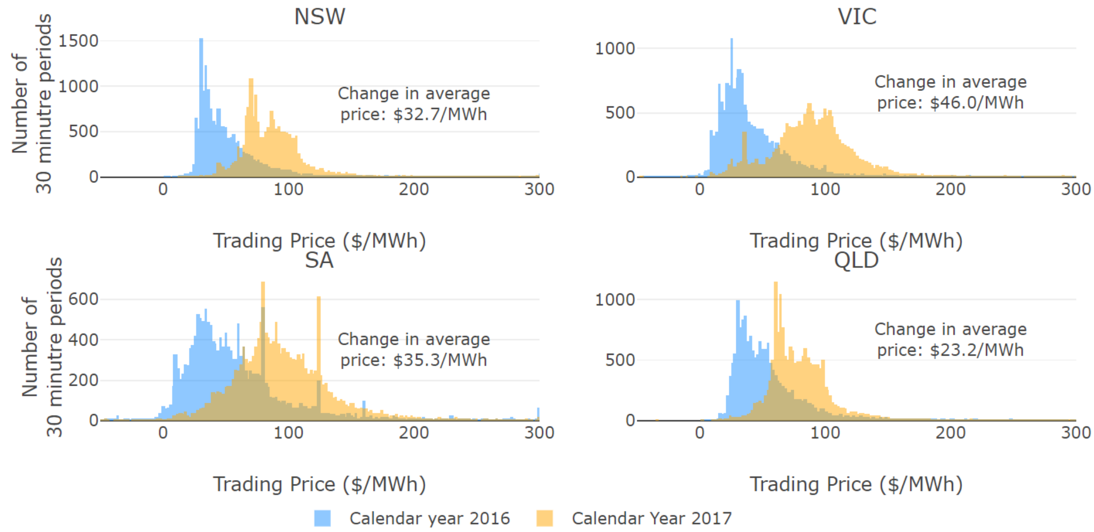
Table 1 presents summary data on the coal generators in the NEM and shows their capacity utilisation in the 2016 and 2017 calendar years.

In July 2017, three months after Hazelwood closed, the Queensland Government directed Stanwell Corporation, the owners of 3300 MW of coal generation in Queensland, to change their bids in order to reduce wholesale prices in Queensland. Additionally, the Queensland Government directed Stanwell to return the 385 MW Swanbank gas-fired power station to service.

[2] As generated value sourced from (Acil Allen Consulting, 2014).
[3] Regional values sourced from (Ball *et al.*, 2017).
[4] The calendar year average of the 5-minute percentage of plant nameplate capacity utilised.

Wholesale prices increased sharply in the NEM after Hazelwood closed as shown in the histograms in Figure 2.

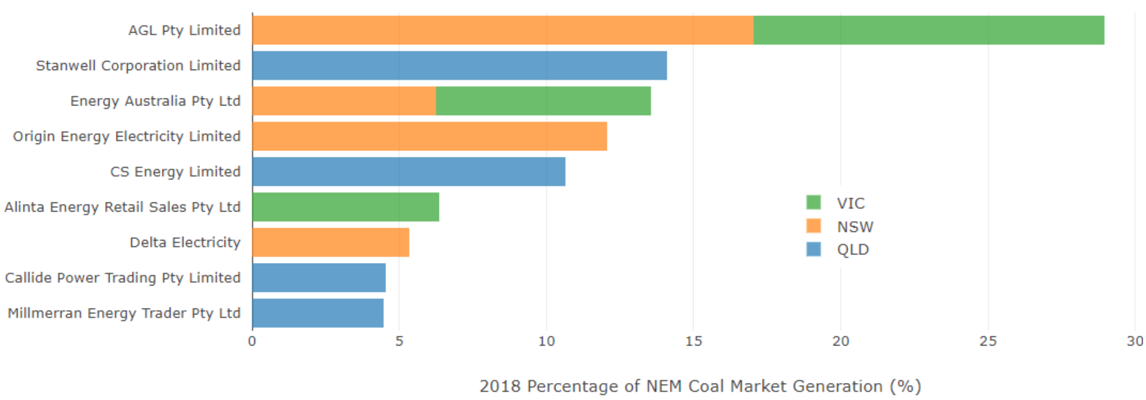
Figure 2. NEM Trading Price Histogram, the change in average price value considers only prices less than $300/MWh.



2.2 Coal generator market share and HHI

Figure 3 describes the market share of the NEM's coal generation, by controlling market participant and NEM region. There are ten coal market participants, with the top four participants responsible for 70% of the coal-fired electricity production; and AGL, on its own, responsible for just under 29% of the coal-fired electricity production in 2018.

Figure 3. Percentage of NEM coal market generation, 2018



Here we examine market concentration using the Herfindahl–Hirschman Index (HHI). In the application to energy markets, HHI measures the total production from each market participant in relation to the total regional production. We apply this focusing only on the coal-fired production segment of the market.

HHI is specified in Equation 1 where MS is the market share percentage of each market participant, i. The HHI can range between close to 0 and 10,000 (where 10,000 is a monopoly (i.e. 100% squared).

$$HHI = \sum_{i=1}^{N} MS_i^2 \tag{1}$$

Table 2 shows a high level of market concentration in all NEM regions since coal output before and after Hazelwood was relatively constant. The HHI in Victoria increased in 2017 when Hazelwood exited, leaving the market to be shared amongst the remaining three producers.

Table 2. Herfindahl–Hirschman Index market concentration measure

	New South Wales	Queensland	Victoria	All regions
2016	3229	3224	2637	1494
2017	3105	3240	3114	1536

An additional feature that affects power system operation and has implications for market power in New South Wales is the very large size of the New South Wales coal generation units (660 MW per unit at Bayswater; 500 MW at Liddell; 700 MW at Mount Piper; 720 MW at Eraring; and 660 MW at Vales Point). These generating units also have minimum stable generation at around 40% of their capacity (except Mount Piper which has a lower level of minimum stable generation) resulting in significant additional inflexibility.

2.3 Regulatory studies of wholesale markets since Hazelwood closed

The Australian Energy Regulator (AER) and the Australian Competition and Consumer Commission (ACCC) have examined aspects of the electricity market since Hazelwood closed.

AER reports

In its first report (see (Australian Energy Regulator, 2017)) focussing on the consequence of Hazelwood closure, the AER concluded that there were features of the New South Wales market "*that likely provide participants with the opportunity to potentially abuse market power*". However, the AER said it needed more time to conclude whether prices reflected the exercise of market power.

In March 2018, the AER published advice on factors affecting the market one year after Hazelwood closure (see (Australian Energy Regulator, 2018a). The advice was commissioned by the Council of Australian Governments and the AER was instructed to examine the response of generators in Victoria and South Australia only; so they ignored the generator bids in New South Wales that feature so significantly in this paper.

In a report at the end of 2018 (see (Australian Energy Regulator, 2018b), the AER reiterated the findings of its December 2017 report: "*Some aspects of the current market structure may make it more susceptible to uncompetitive outcomes*". However, it did not assess the extent to which market participants are exposed to spot prices; and the AER said it would need more data on contract market positions before it could conclude whether generators had an incentive to exercise market power.

ACCC report

As part of a comprehensive review of the electricity market (see - (Australian Competition and Consumer Commission [ACCC], 2018), the ACCC examined wholesale markets. It concluded that "*the current wholesale market structure is not conducive to vigorous competition*" (p. 88) and that higher wholesale prices are attributable to "*a subtle and sustained 'lift' in prices that can be attributed in part to a lack of competitive constraint*" (p. 96). In 2014, the ACCC opposed the acquisition of the Bayswater and Liddell power stations by AGL (ACCC, 2014), but its decision was overruled by the Australian Competition Tribunal.

3 Market power analysis

3.1 Conceptual framework

The literature reveals different definitions of market power. Biggar (2011) suggests that the broad consensus is that market power is said to exist when a firm has some influence over the market price. However, the literature often contrasts imperfect markets with imperfect regulation - see for example (Levine, 2002) - and accordingly a more demanding definition for market power is appropriate. For example, the Australian Productivity Commission adds the qualifier that market power exists if firms can profitably sustain prices above efficient costs for a significant period of time (Productivity Commission, 2012). Others use similar qualifiers. For example, Baumol et al. (1999) define market power as the power to "*prevent entry of competitors and to raise prices substantially above competitive levels*" , and Klein (1993) suggests that market power consists in "*the ability to cut back the market's total output and so raise price*".

The exercise of market power can have distributional effects (transferring wealth from consumers to producers) and efficiency detriments. Efficiency detriments arise from the substitution of less expensive for more expensive production (when market power is exercised by lower cost producers) and through loss of consumer surplus (when opportunities for consumption are avoided in the presence of artificially higher prices). Other detriments associated with less competition include slowed innovation (Hashmi, 2013) and a slow-down in productivity growth (Eeckhout *et al.*, 2017).

Borenstein et al. (2002) identify two techniques to distinguish market power. The first is to assess whether a firm is able to significantly affect the price in a market by changing its output or its offer prices. The second is to examine whether the market as a whole is setting competitive prices considering the costs and technical characteristics of the producers. This approach is effective for estimating the scope and severity of market power and how competitive outcomes vary over time (Borenstein, Bushnell and Wolak, 2002). Literature mainly in this (second) tradition (although sometimes also in the first tradition) includes (Green and Newbery, 1992; Borenstein and Bushnell, 1999; Wolfram, 1999; Borenstein, Bushnell and Wolak, 2002; Mansur, 2004; Bushnell, Mansur and Saravia, 2008; Joskow and Kohn, 2011;

Woerman, 2018a) (Hortac, 2008). This is the approach we begin with in this paper, but like several of the cited studies and following Borenstein et al. (2002), we also examine market power at the level of the firm, to identify more precisely the nature and origin of the market power that we hypothesise.

In contrast to the many academic studies of market power in electricity markets in North America and Europe, as far as we know, this is the first academic study focussing specifically on market power in Australia's electricity market, and is certainly the first that focusses on the market only when coal generators set market clearing prices.[5]

Coal generators form the "base load" of electricity production in the NEM. Wind and solar producers typically offer their production to the market at zero or negative prices. On the basis of production costs, coal generation is the next cheapest source of electricity production followed by gas and hydro power stations.[6] Wind and solar does not compete with coal generation on price, and instead is best understood as negative demand.

Our approach means that we exclude from the analysis, all those instances where prices are determined by more expensive gas, hydro, oil or diesel generators. At the top of the coal generation supply curve, coal competes with gas and hydro generators. Gas (and hydro) generators set a price ceiling for coal generators' prices. For example, in what it described as the "strategic rationale" for its acquisition of the Bayswater and Liddell Power Stations, AGL identified at the time of acquisition, that there was

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[5] In addition to the paucity of academic study of market power in the NEM, there is almost no studies on market power by regulators. The Australian Energy Regulator produces reports that describe the circumstances when prices exceed a threshold level, but this has not ever led to a firm conclusion on the existence of market power. The Australian Energy Markets Commission (see – (Australian Energy Markets Commission, 2013) studied the existence of market power in the NEM in response to a request by a customer group for changes to the market rules. The AEMC defined a "workably competitive market" as one in which average prices in the market were not far above the AEMC's estimate of "long run marginal cost", i.e. the average cost of a new entrant. Using this approach, the AEMC concluded in 2013 that the NEM was workably competitive since the prices the generators received were not above the AEMC's estimate of the average cost of new entrants. If asked to assess the existence of market power now, no doubt the AEMC would come to the same conclusion since, although the generators received prices several times their production costs, these prices are probably still lower than the average cost of new coal-fired generators.
[6] Run-of-river hydro dominates production in Tasmania, but we have restricted our study to the AC-interconnected markets in the NEM.

a $40/MWh "headroom" between the production cost of these coal generators and the cost of generation from the cheapest gas generators (see AGL Energy Limited, 2014).

By focusing only on those times that coal generators set prices, we are able to isolate the competitiveness of this part of the supply curve, and we can identify the spot market revenues when coal generators set prices. Thus we can avoid other complications (such as gas prices and the competitiveness of the peaking part of the supply curve) that affect the exercise of market power when coal generators are not setting prices.

To put our approach in context, Figure 4 shows the percentage of all 5-minute trading periods in which the spot price is determined by a coal-fired generator. It shows that a little over half the time, coal generators set the market clearing prices. Figure 5 shows the percentage of the electrical demand in each year that is provided by the market when coal-fired generators set prices. It shows reasonable correspondence to the percentage of time that coal sets spot prices.

Figure 4. Percentage of time spot price is set by coal-fired generators in each calendar year

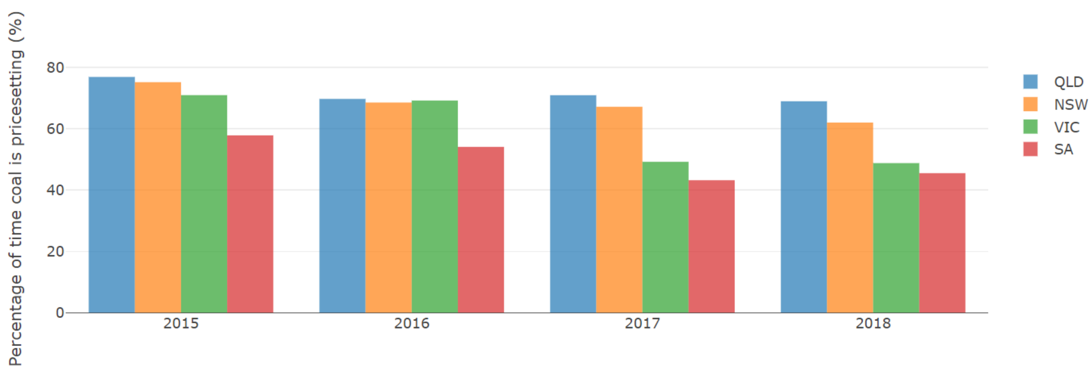
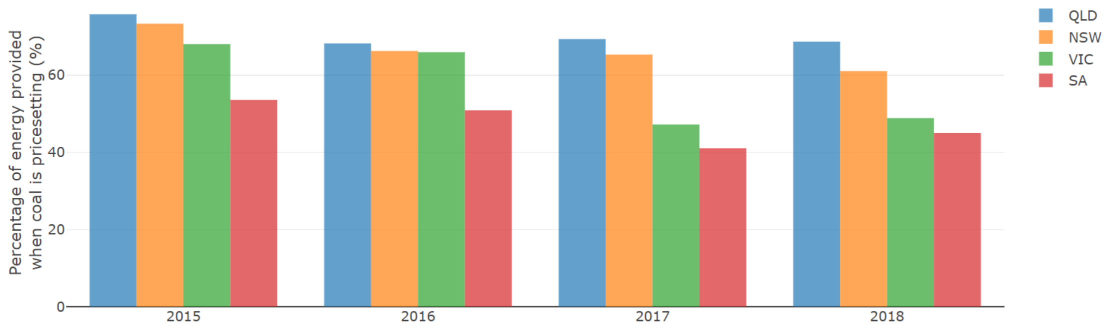


Figure 5. Percentage of demand that is provided when coal-generators set prices



Our hypothesis of the pricing strategy that maximises proceeds from the exercise of market power after Hazelwood's closure follows a model of oligopolistic competition set out in Woerman (2018b) in a study of market power in the Texas electricity market, which in-turn follows closely the model of Ryan (2017) in a study of the Indian electricity market. The key construct in this model that is of relevance to our study is the optimal mark-up rule for the i^{th}'s plant's k^{th} offer price. This is established by taking the first difference of the (profit maximisation) objective function[7] with respect to the offer price of the i^{th} plant, and is expressed as the ratio of the expected revenue (the production that clears the market and that is paid the uniform market clearing prices) divided by the negative of the slope[8] of the plant's expected residual demand when this offer price clears the market. The residual demand is the market demand plus interconnector import less production met by all other generators. The numerator is maximised when inframarginal rents[9] are maximised (in other words, when a firm has more inframarginal rent in the market, the cost curve should have a higher gradient and the generator has more incentive to exercise market power by increasing the price of its bids). The denominator is minimised (and hence mark-ups maximised) when the residual demand is inelastic with respect to the market price

[7] The objective function is the maximisation over a firm's portfolio, of the difference between revenues (in spot and forward markets) and production costs.
[8] The partial differential of the expected residual demand with respect to the market price.
[9] Where inframarginal rent is the difference between the market price and the minimum price at which the generator would have a desire to generate.

(in other words, a firm has the greatest ability to exercise market power when its competitors are least able to respond).

3.2 Analysis

We describe and analyse coal generator prices and volumes before proceeding to the analysis of inter-regional power flows, and spare coal production capacity for each five-minute period in each of the four mainland NEM regions and between Victoria, New South Wales and Queensland over the period from 2015 to 2018. This sequence of description and analysis provides an understanding of the relationship between generators' offers and their consequent production, and the resulting spot market prices, inter-regional power flows and the level of unused coal generation capacity that was available when coal generators were setting prices. This provides the primary evidence for the first part of our test of our hypothesis that prices may reflect the exercise of market power rather than genuine scarcity. From this, we evaluate the extent to which changes in coal prices can explain changes in electricity prices. We then examine (unpriced) coal supply constraints, and then conclude on the nature and the extent to which the exercise of market power by coal generators can explain the observed market outcomes when coal generators set spot prices, since Hazelwood closed.

3.2.1 Prices

In presenting the evidence, we start by examining the offers that the generators made in the period from the start of 2015 to the end of 2018. Figure 6 to Figure 10 shows, for each of the New South Wales generators, the volume of their production (the solid line) and the prices that they offered their production to the market at. Colour is used in these charts to show the different bands at which capacity is priced for each generator.[10] The date at which Hazelwood's closure was publicly announced and the date of the closure is also shown in the charts. These are important dates in understanding how generators changed their offers. In the inspection of these charts, we draw attention to the following:

[10] These figures are created by analysing the AEMO BIDPEROFFER and BIDDAYOFFER bids submitted for each generation unit in a power station. The final offer is used. A daily average of the latest bids was used for all five minutes in each day, and data from all the generator's units were summed to form the station figures. Plant generation (the bold line) shows the weekly average of the plant output.

1. In Figure 6 we see that immediately after the Hazelwood closure was announced, AGL withdrew about 500 MW that it had previously offered to the market in the $40-$60/MWh (red band), and only offered to make this capacity available at prices of more than $5,000 per MWh (light blue band). Figure 7 shows that AGL repriced around 400 MW at its Liddell Power Station in the same way.
2. Inspecting Figure 8 to Figure 10, we see that none of the other generators repriced their output until the start of 2017. In Figure 6 we see that around the start of 2017, AGL again re-priced capacity at Bayswater, this time from the $20-$40/MWh to the $40-60/MWh bands.
3. AGL and the other generators (except Eraring) re-priced capacity upwards again about a month before Hazelwood closed and Eraring followed suit when Hazelwood closed.

Figure 6. Bayswater Power Station (AGL)

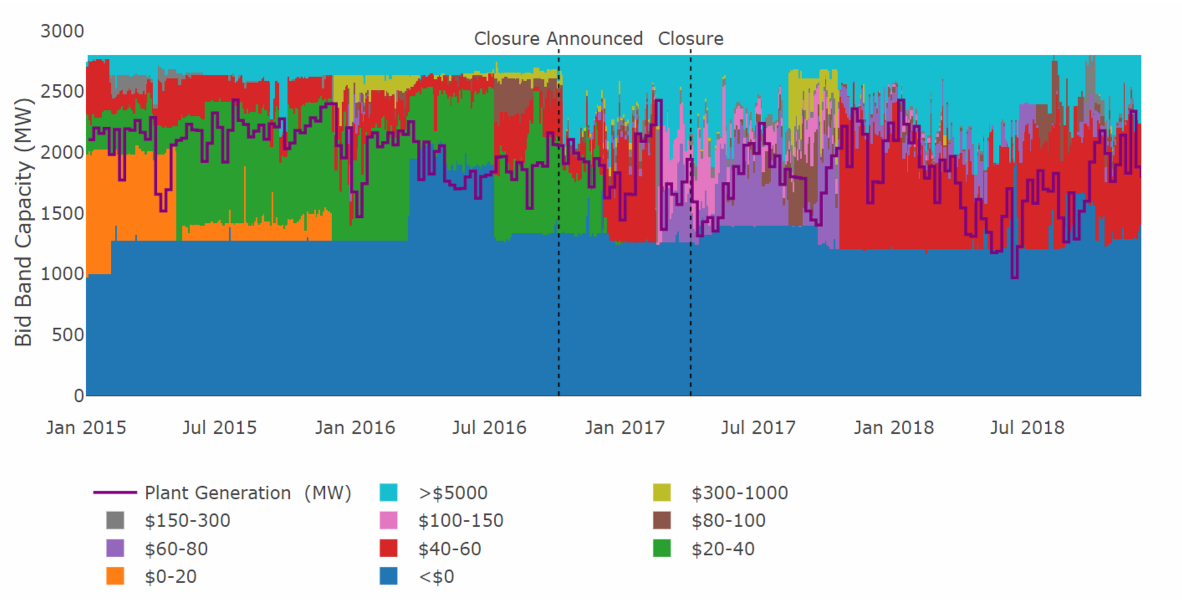


Figure 7. Liddell Power Station (AGL)

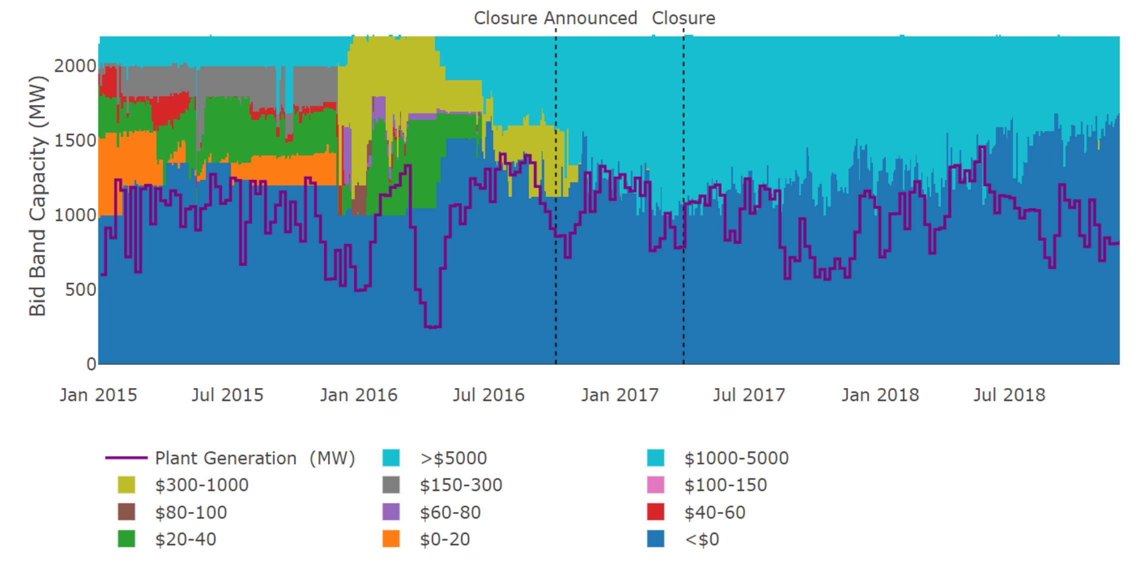


Figure 8. Eraring Power Station (Origin)

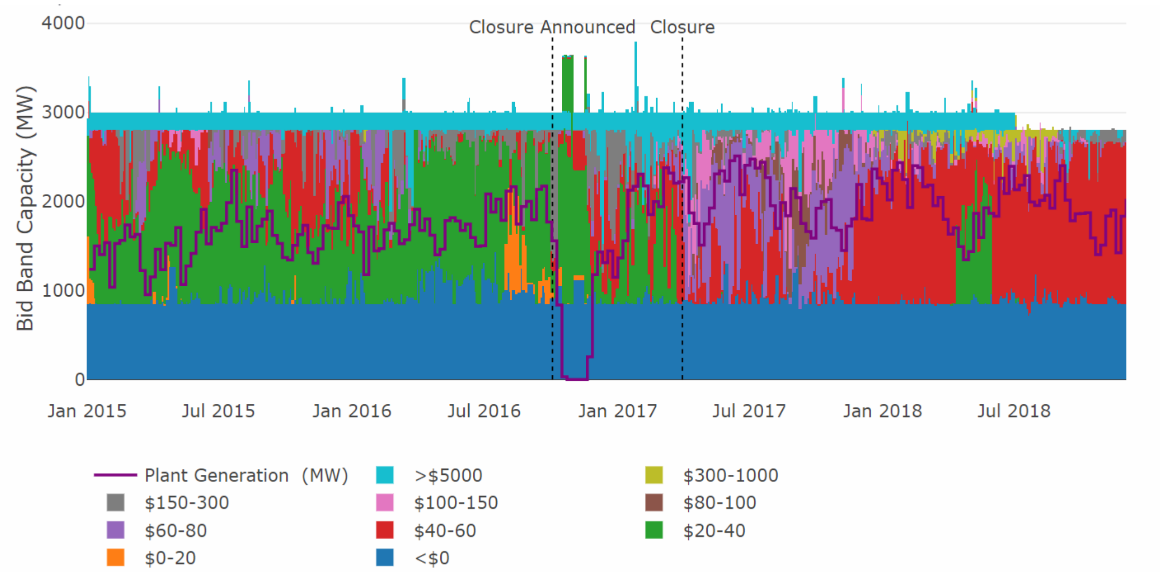


Figure 9. Mt Piper Power Station (Energy Australia)

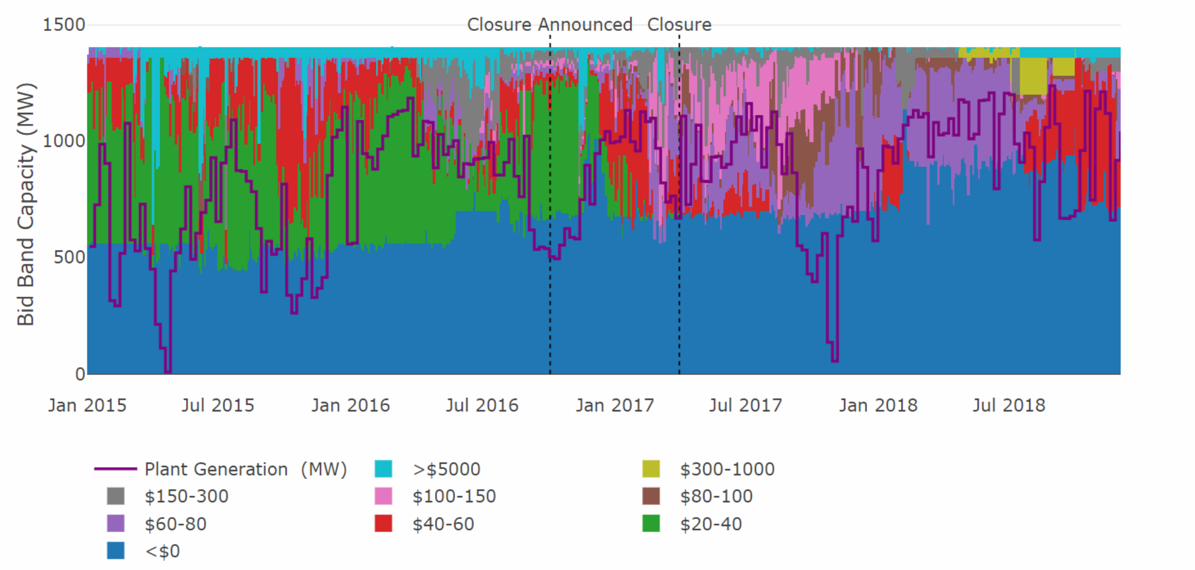
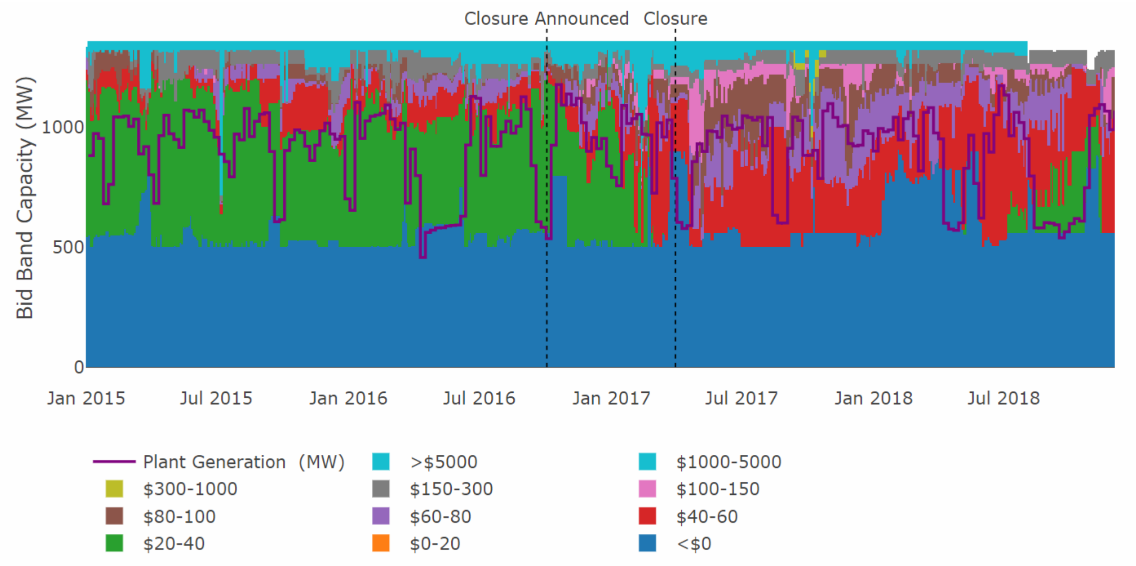


Figure 10. Vales Point "B" Power Station (Delta)



The price/volume traces of the Victoria and Queensland coal generators (see Appendix A) show that none of the Victoria generators re-priced after the New South Wales generators, and in Queensland only Gladstone shows a pattern that might suggest some re-pricing.

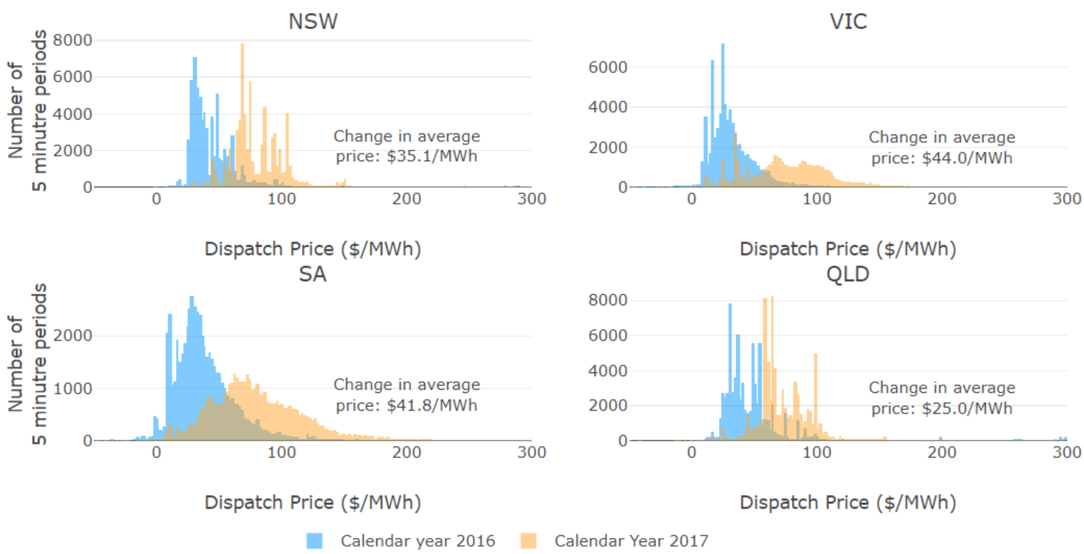
We eliminate from contention the prospect that any of the three Victorian brown coal generators had attempted to exercise market power, on account of the fact (see Table 1) that they had all been dispatched close to full capacity since Hazelwood closed:

evidently they had priced their production not to withhold production from the market.

Other than the New South Wales generators, this leaves the possibility that some of the Queensland coal generators had priced their production so as to exercise market power. However, none of these generators repriced capacity in the way the New South Wales generators did. We can be confident that Kogan Creek, Milmerran and Tarong North had limited ability to produce much more than they did (see Table 1). Tarong and Stanwell might have been able to expand production, but after considering their capacity, capacity factor and interconnector transfer limits, it is doubtful that this would have had much of an impact on prices in either Queensland or New South Wales.

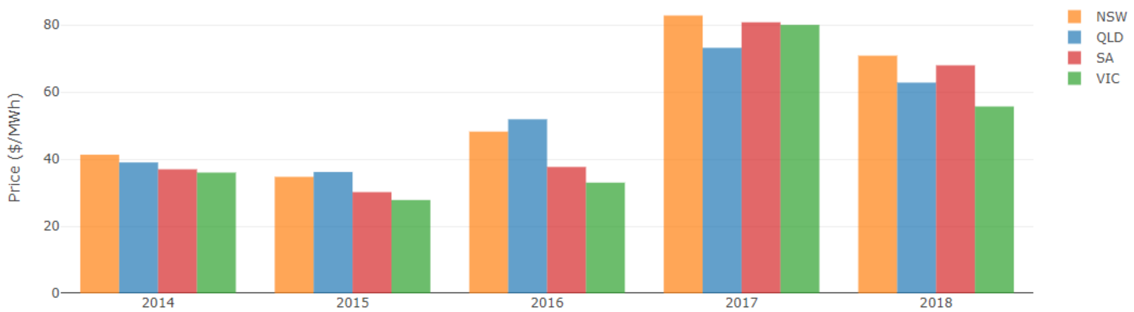
The outcome of the generator re-pricing lead by the New South Wales coal generators is visible in a histogram of the spot prices for the calendar year before and after Hazelwood closed (when coal prices set those prices) as shown in Figure 11 below.

Figure 11. Five-minute price histograms when coal is setting the regional reference price



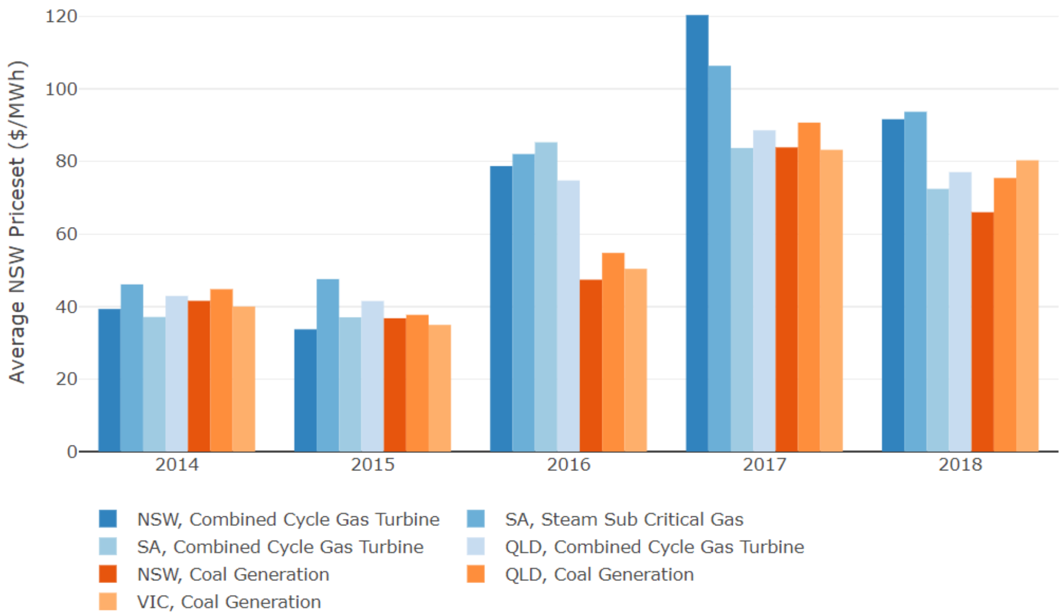
The impact of the change in the prices offered by the coal generators can be expressed in the weighted average spot prices in each market when coal generators set the spot prices. This can be seen in Figure 12 below which shows that spot prices calculated in this way roughly doubled in all markets in the year that Hazelwood closed, although prices in 2018 have declined somewhat to lie roughly in between the prices in the year before Hazelwood closed and the year after it closed (although they have increased again in the first quarter of this year).

Figure 12. Weighted average spot when coal generation sets market prices



Analysing the difference between the marginal price setting values of coal and gas in NSW (Figure 13) finds that after 2016, coal generators increased their bids to shadow gas CCGT generation prices. The increase in gas marginal price setting values in 2017 is likely to be in part higher gas prices, but even more that, higher coal bids provided a higher floor for the prices offered by gas generators.

Figure 13. Average price when generation sets NSW spot price[11]



[11] These values were calculated by averaging only the five-minute prices when these generation technologies were setting spot prices in NSW.

3.2.2 Quantities

Firstly, to exclude the possibility that market prices before and after Hazelwood closed were affected by increases in demand, we show histograms for each region, of the demand for the calendar years before and after closure (Figure 14). This shows that there was not a significant change in demand for all five-minute periods for any NEM region between the two years.

Figure 14. Histogram of demand for each region before and after closure

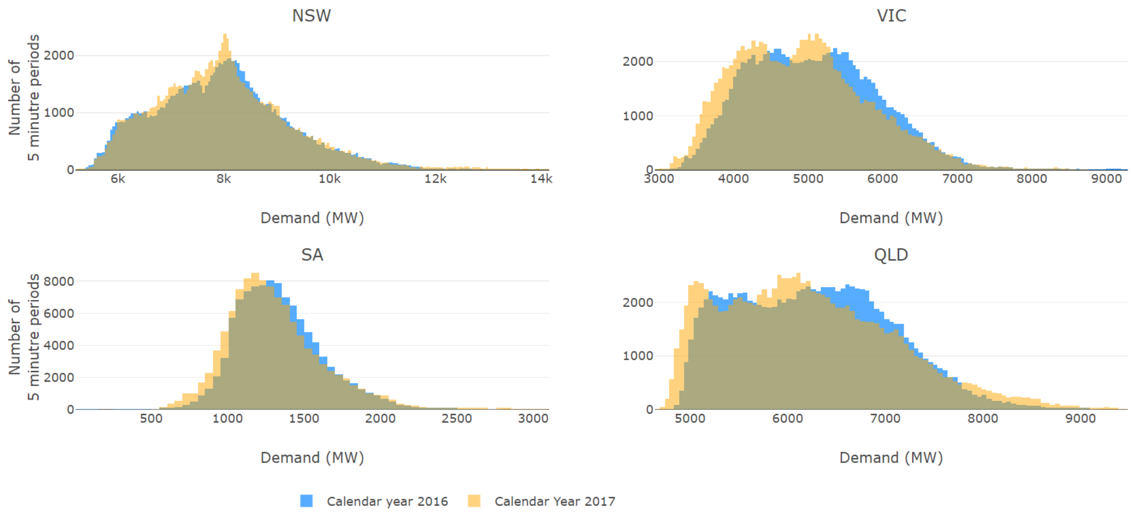


Figure 15 to Figure 19 show the hourly production of each New South Wales generator for the years 2016 to 2018. The solid lines are the average production for each year and the coloured bands show the interval within which 90% of all observations are likely to lie. The production displayed in these charts follows from the prices that each generator offered into the market as shown in Figure 6 to Figure 10. The changes in the annual production of each generator is thus an expression of the change in their prices relative to each other (and relative to all other generators in the NEM when interconnectors are unconstrained). We draw attention to the following:

1. In Figure 15 we see that in 2017, Bayswater's production reduced late at night, early in the morning and during the middle of the day, but during the morning and evening peaks it was much the same as in 2016. In 2018, Bayswater's capacity was made available to the market at a price that ensured

that throughout the day it was being dispatched, on average, about 300 MW less in 2016.

2. Figure 16 shows that in 2017, Liddell's production was typically around 150 MW lower after Hazelwood closed than before it closed. By 2018 AGL had set prices at Liddell so that it increased production back to the level it was producing at in the year before Hazelwood closed.
3. Figure 17 shows that for Eraring, Origin's re-pricing resulted in around 500 MW more production throughout the day in the year after Hazelwood closed. In 2018 production was a little lower, mainly during the peak periods.
4. Figure 18 shows that Mount Piper's production declined mainly during the day in 2017 by around 50 MW, but increased throughout the day and night in 2018 by around 200 MW relative to the year before Hazelwood closed.
5. Figure 19 shows that for Vales Point, production increased slightly during the day in 2017, but declined mainly during the day in 2018 following a five-week planned outage of one of its two units.

Figure 15. Bayswater Power Station daily generation profile showing the 5-minute daily mean profile and 10/90% probability of exceedance band

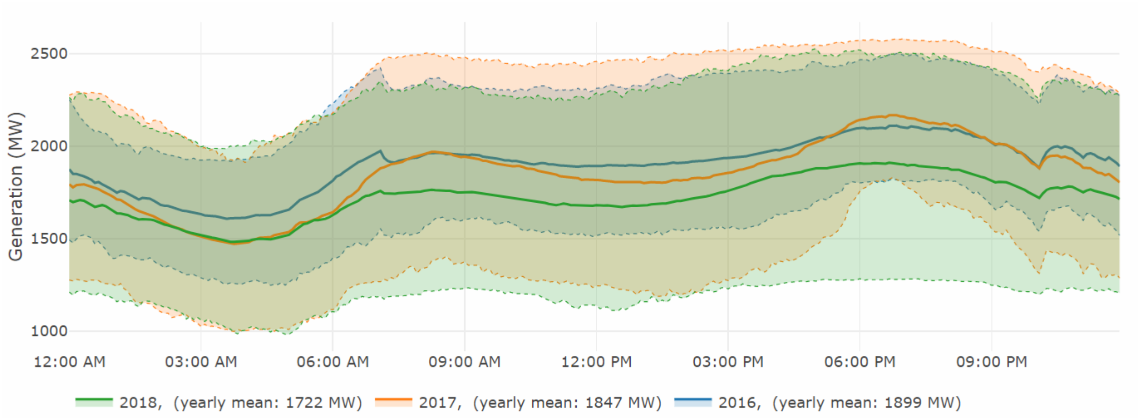


Figure 16. Liddell Power Station daily generation profile showing the 5-minute daily mean profile and 10/90% probability of exceedance band

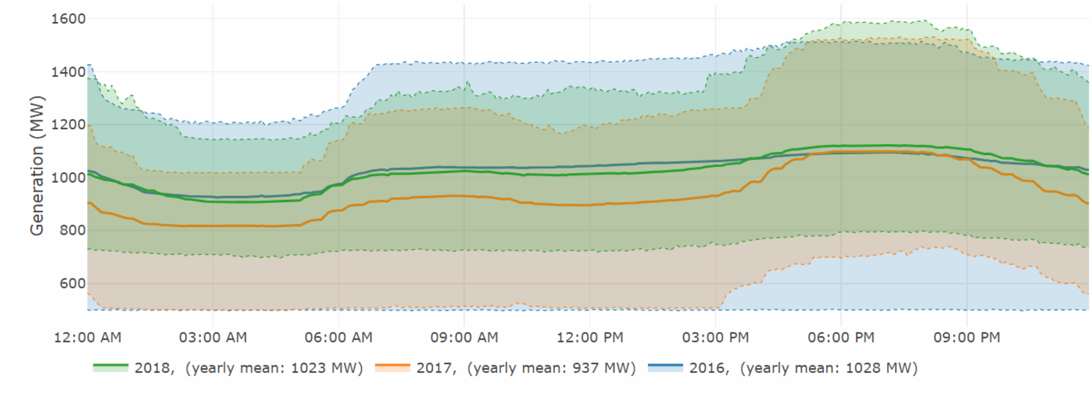


Figure 17. Eraring Power Station daily generation profile showing the 5-minute daily mean profile and 10/90% probability of exceedance band

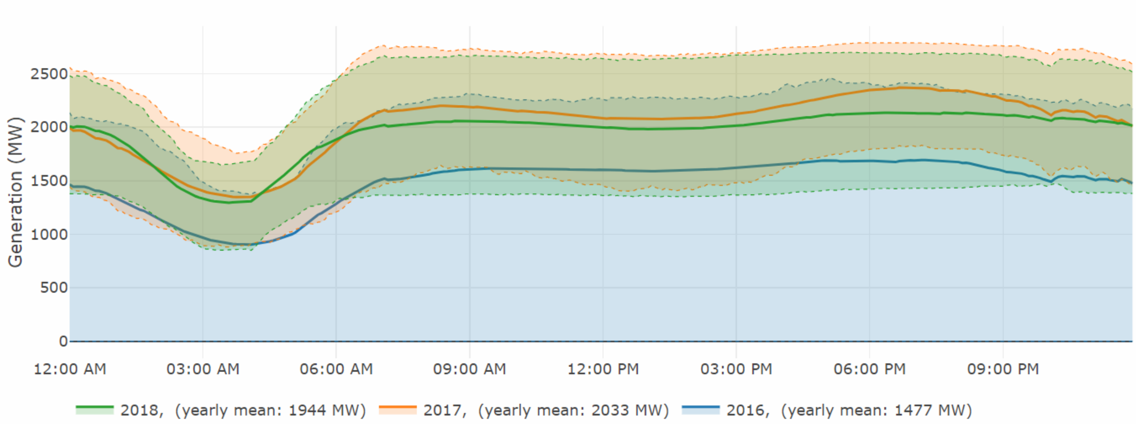


Figure 18. Mount Piper Power Station daily generation profile showing the 5-minute daily mean profile and 10/90% probability of exceedance band

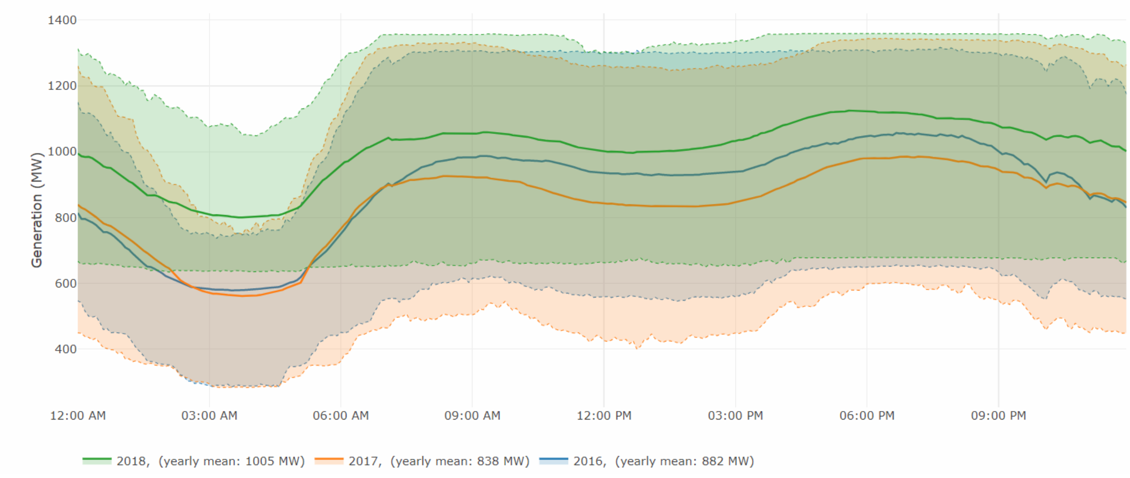


Figure 19. Vales Point "B" Power Station daily generation profile showing the 5-minute daily mean profile and 10/90% probability of exceedance band

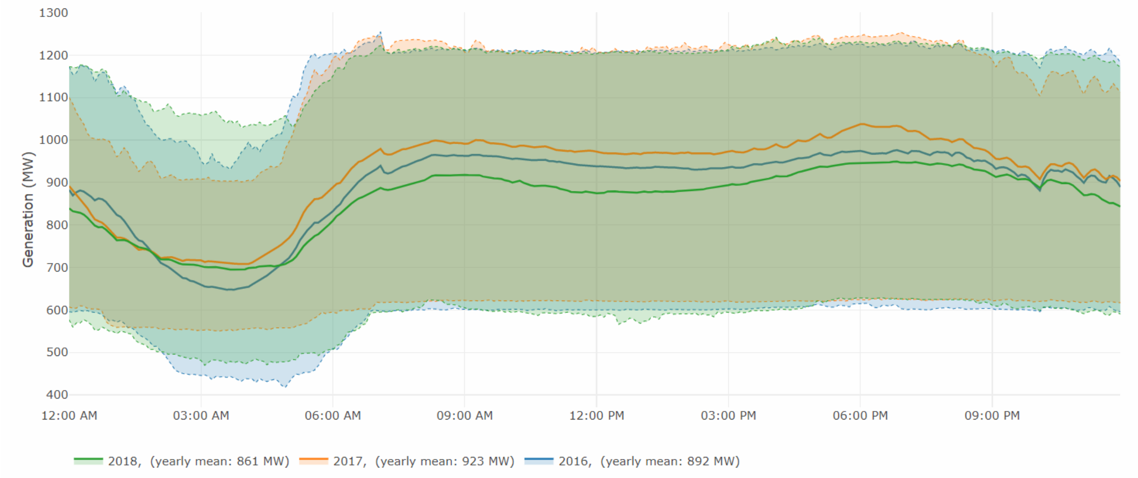
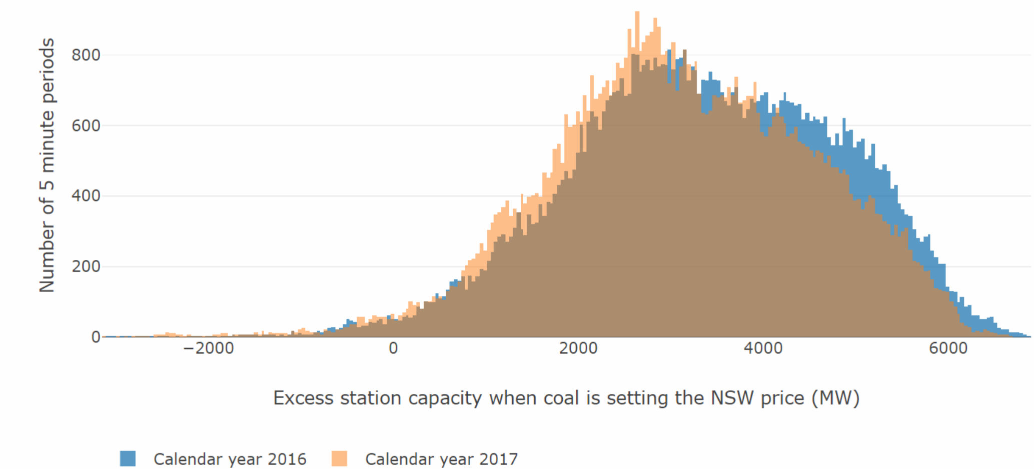


Table 1 showed that, calculated as an annual capacity utilisation rate using nameplate capacity, coal generators in New South Wales had lower utilisation before and after Hazelwood closed relative to generators in Victoria and Queensland. Building on from this and to dismiss the argument that the New South Wales generators' bids reflected production scarcity, Figure 20 below shows a scatter of the capacity available in the market for each five-minute dispatch period when any of the New South Wales coal generators was setting the spot price in New South Wales. It is obvious from this that for all but a few trading periods, there was plenty of spare New South Wales coal generation capacity (whether or not that spare capacity is measured by its nameplate capacity or its available capacity). There can be little doubt that the higher prices when coal generators were setting prices cannot be explained by scarcity of production capacity, because such scarcity rarely existed.

Figure 20. Spare capacity (using nameplate capacity) when coal-fired generation was setting the price in New South Wales



3.2.3 Inter-regional trade and prices

The generator re-pricing in New South Wales, and to a lesser extent in other states, had a significant impact on inter-regional power-flows and the extent to which higher prices in New South Wales were transmitted into the neighbouring markets.

Trade between New South Wales and Victoria

Figure 21 is a histogram of the number of 5-minute settlement periods corresponding to the measured flow (x-axis) on the interconnector between Victoria and New South Wales (a positive value denotes a flow from Victoria to New South Wales). It shows that before Hazelwood closed, for all but a handful of settlement periods Victoria was exporting electricity to New South Wales. After Hazelwood closed, Victoria's exports declined, but it was still exporting more and more frequently to New South Wales than it was importing.

Figure 21. Histogram of the Victoria-New South Wales interconnector flow (positive amounts are flows from Victoria to New South Wales)

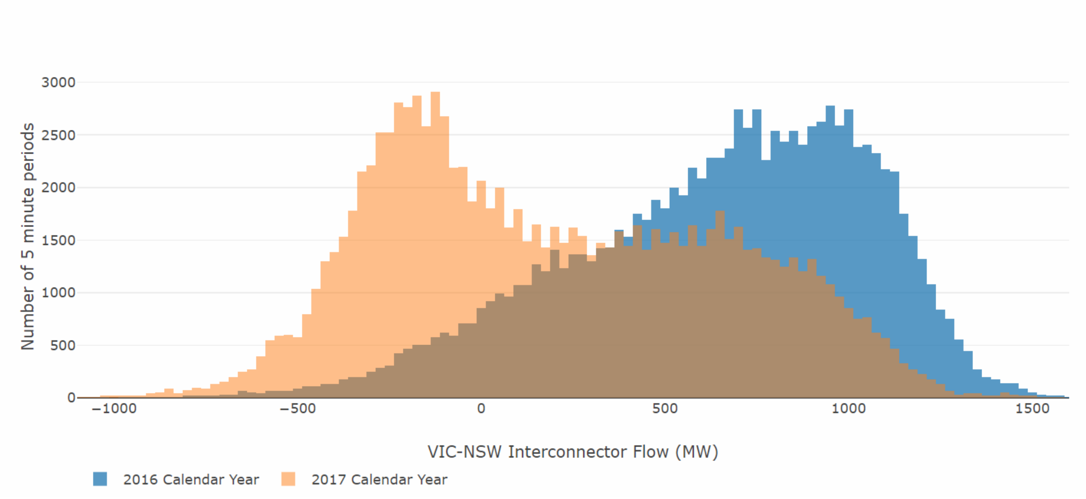


Figure 22 shows a trace of the average half-hourly flows when Victoria was exporting to New South Wales from 2016 to 2018, and the bands within which 90% of all observations lie. It shows that Victoria exported the most in the early morning and the least during the day, and that after Hazelwood closed Victoria's exports roughly halved from 656 MW on average to 318 MW (in 2017) and 363 MW (in 2018).

Figure 22. New South Wales imports from Victoria showing the 5-minute daily mean profile and 10/90% probability of exceedance band

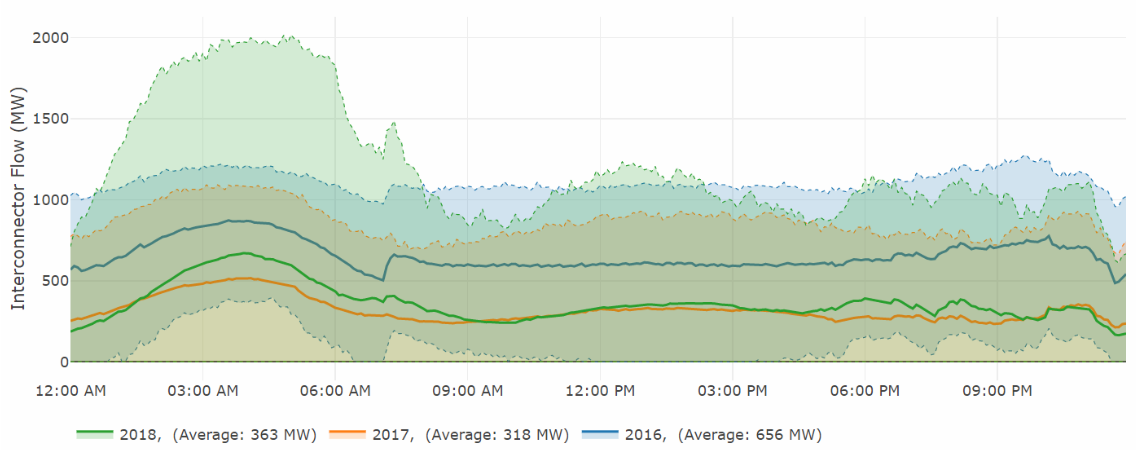
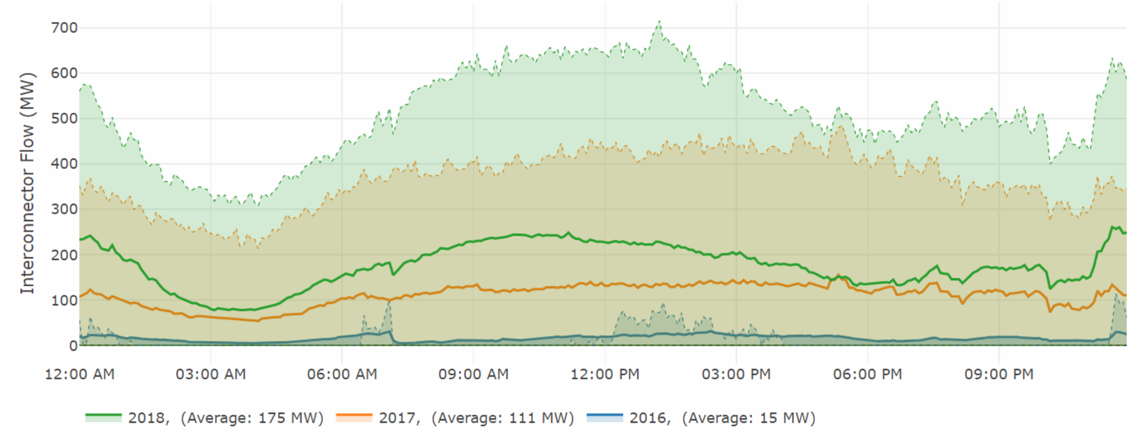


Figure 23 shows that before Hazelwood closed, New South Wales exported negligible amounts to Victoria, but after the closure it exported around 100 MW, and by 2018 this had risen to around 150 MW on average. The 90% probability band however shows significant exports from New South Wales to Victoria (up to around 700 MW at times).

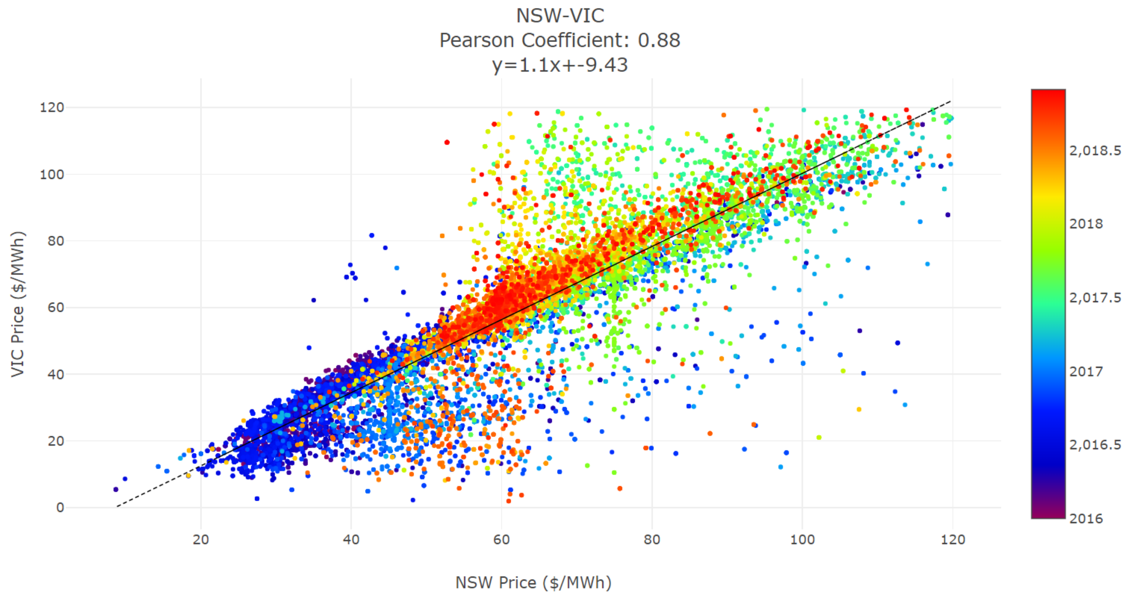
Figure 23. New South Wales exports to Victoria showing the 5-minute daily mean profile and 10/90% probability of exceedance band



Comparing these figures, we see that even if Victoria is (roughly) as likely to be exporting to New South Wales as importing from it in any settlement period, even after Hazelwood closed, the average and peak exports from Victoria to New South Wales remained much larger than the average and peak exports from New South Wales to Victoria.

The scatter plot in Figure 24 shows how prices in the Victoria and New South Wales markets correlate. The Pearson Product Moment Coefficient shows a strong correlation (0.88), and this is seen in the proximity of most dots to the line of best fit. The chart also shows that particularly during 2017, prices in Victoria separated from those in New South Wales (the lighter green dots above the line), indicating that at these times Victoria needed to import more than the interconnector could carry and so prices separated from those in Victoria. Converesly in 2018, dispersion both above and below the line is frequently seen. The red dots below the line show that at several times in 2018, prices between New South Wales and Victoria separated when the interconnector was not able to carry the exports required, and hence during these periods, Victoria was effectively not able to "import" the higher prices through connection to New South Wales.

Figure 24. Scatter plot of settlement period prices in Victoria compared to those in New South Wales



Trade between New South Wales and Queensland

Figure 25 shows that after Hazelwood closed, Queensland more frequently exported to New South Wales.

Figure 25. Histogram of the Queensland-New South Wales interconnector flow (positive amounts are flows from Queensland to New South Wales)

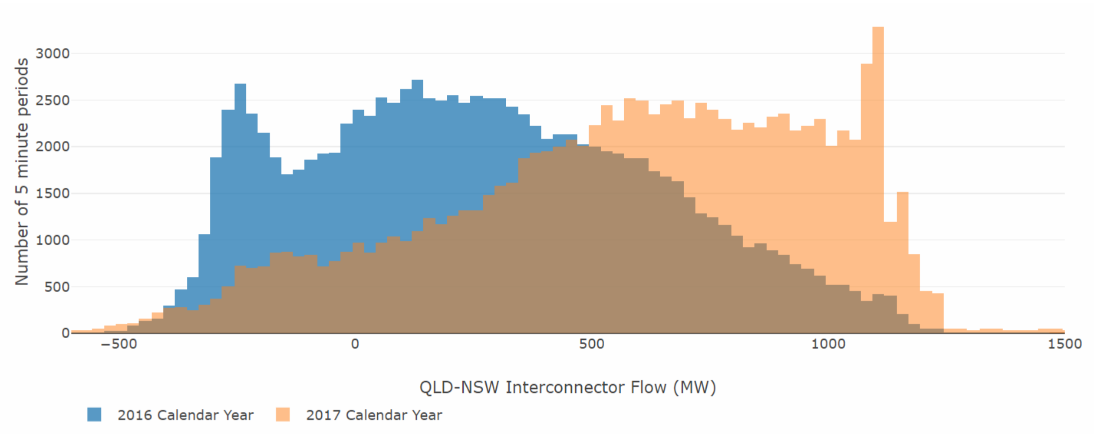


Figure 26 shows that across the day, Queensland exports to New South Wales roughly doubled in the year after Hazelwood closed and increased again in 2018. In round terms, Victoria's lost exports to New South Wales were replaced by Queensland exports to New South Wales of about the same amount.

Figure 26. New South Wales imports from Queensland showing the 5-minute daily mean profile and 10/90% probability of exceedance band

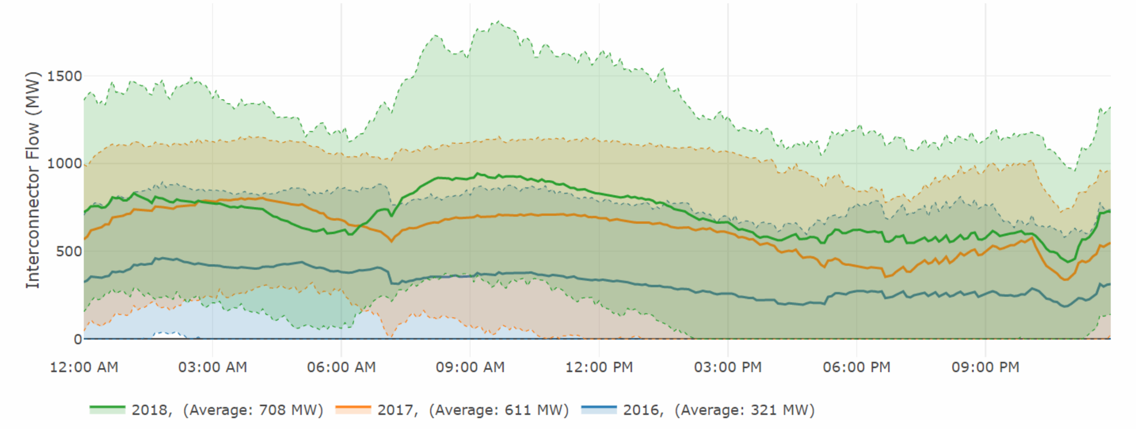


Figure 27 shows that exports from New South Wales to Queensland declined from around 70 MW during the afternoon and evening. Particularly notable is the reduction in the size of the 10/90% probability band after Hazelwood closed.

Figure 27. Export from New South Wales to Queensland showing the 5-minute daily mean profile and 10/90% probability of exceedance band

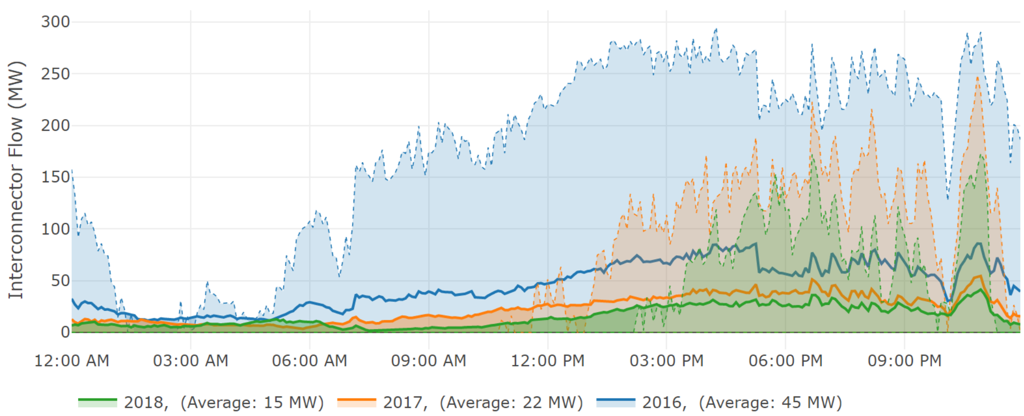
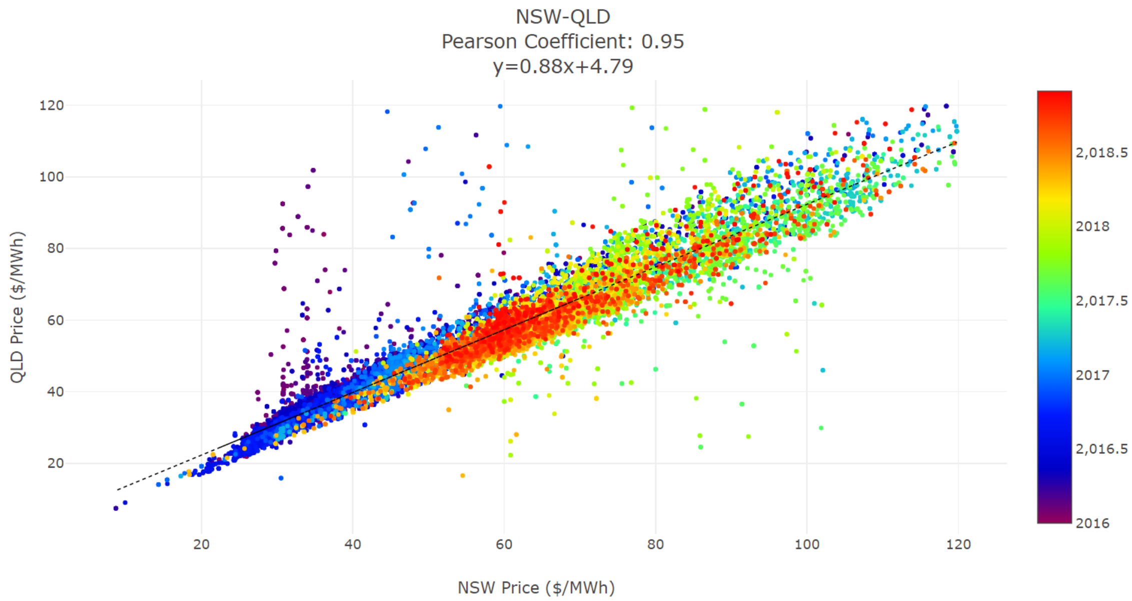


Figure 28 shows that New South Wales and Queensland prices are very highly correlated (95% Pearson coefficient) and prices in the two markets rarely deviate. Clearly price changes transmit between markets easily both before and after Hazelwood closed.

Figure 28. Scatter plot of prices in New South Wales compared to those in Queensland at the same times

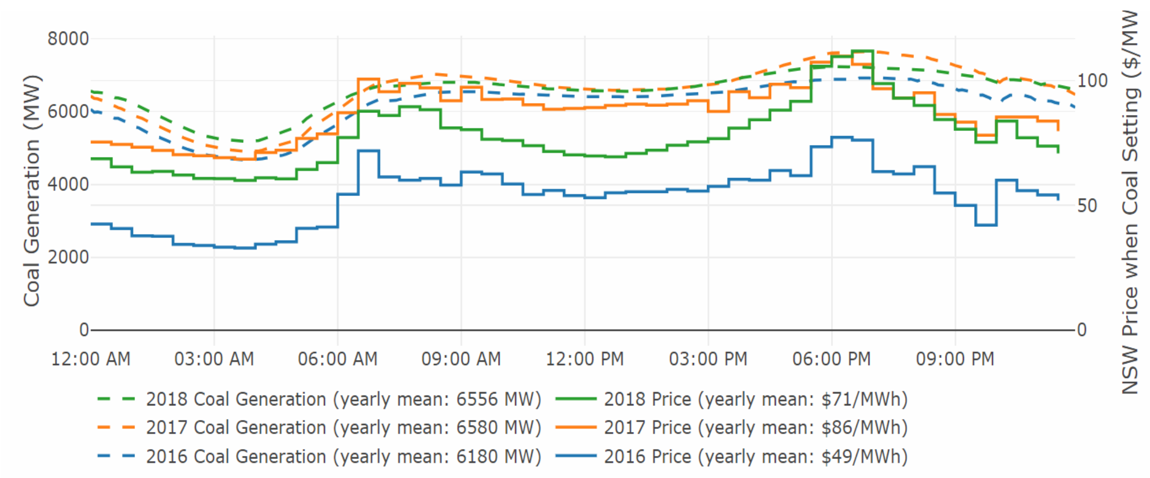


3.2.4 Summary

Figure 29 shows the aggregate half-hourly profile of New South Wales coal generators' production and the spot prices in New South Wales, when any of these generators were setting them.[12] It shows that on average New South Wales' coal generators produced 400 MW (6%) more after Hazelwood closed, but average New South Wales prices (when coal generators were setting them) increased from $49/MWh to $86/MWh (76%).

[12] This process selects the time instances when a coal-fired generator located in any region in the NEM sets the 5-minute price in New South Wales.

Figure 29. Spot price in New South Wales when coal generators anywhere in the NEM set the price, and New South Wales coal generation average production



3.3 Might the outcomes reflect the exercise of market power?

The closure of Hazelwood meant the loss of 10.1 TWh of production (based on Hazelwood's production in the last full calendar year). If, hypothetically, all of this was to be made up for by increased production by coal generators in New South Wales, this would have required an increase of 14% of their production in 2016. In the event, in the calendar year that Hazelwood closed, aggregate additional annual coal generation of 4.2 TWh[13] occurred, of which 3.5 TWh was from generators in New South Wales, 0.5 TWh from Queensland and 0.2 TWh from Victoria.

Since most Queensland and Victorian coal generators were highly utilised before Hazelwood's closure, the obvious source of additional replacement capacity was from the five generators in New South Wales, all of whom had substantial unused capacity. Yet in the year that Hazelwood closed, both power stations owned by AGL decreased production, Energy Australia's Mt Piper station slightly decreased production, and Sunset Power's Vales Point slightly increased production. Only Origin Energy's Eraring Power Station significantly increased production. Since production is determined by success in the five-minute auctions, these changes reflect the respective generators' re-pricing of their offers in the wholesale market.

[13] After adjusting for Hazelwood's production in the last 3 months of the 2017 calendar year.

Review of these offer data earlier showed that AGL led the repricing with a step change at Liddell and a series of step changes at Bayswater, starting around the time that the Hazelwood closure was announced, again at the start of the calendar year and again when Hazelwood closed. The other New South Wales generators followed this pattern, although to a lesser extent as reflected in the change of their production (relative to AGL's) after Hazelwood closed.

We can be certain (recall Figure 20 earlier) that there was no enduring scarcity of electricity production capacity in New South Wales. At the vast majority of Settlement Periods when coal capacity was setting spot prices in New South Wales, there was plenty of other New South Wales coal generation capacity available, even leaving aside coal capacity in other interconnected states. None of the generators suggested to us that a scarcity of production capacity explained prices.

We turn to the impact of changes in coal prices later, to conclude that these cannot explain the change in generator offers prices.[14] Rather, leaving aside unpriced constraints discussed in more detail later, the traces of the average production across the day for AGL's Loy Yang Power station in Victoria and its Bayswater and Liddell stations in New South Wales is consistent with the model of oligopolistic competition we hypothesise. Specifically, the production charts (see Figure 15 and Figure 16) show the largest reduction in Bayswater and Liddell production during low demand periods from late evening to early morning and comparable production (to that before Hazelwood closed) during the higher demand periods. Since inframarginal rents[15] for coal generators will be maximised when non-coal generators were setting prices (see Figure 30), this means that consistency with the optimal mark-up rule will show these plants maximising production during peak demand periods and minimising it in the off-peak periods when coal was most likely to be setting price.[16] This is what we see

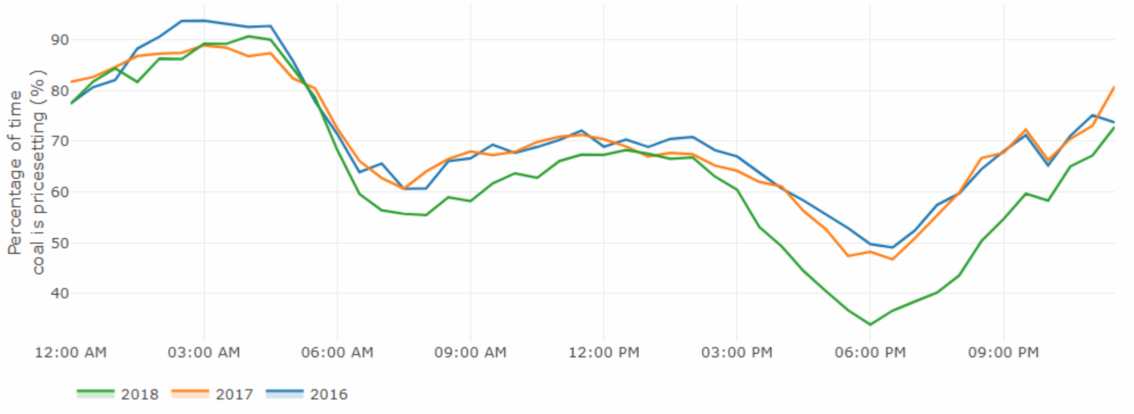
[14] In testimony to the New South Wales Parliamentary Select Committee, AGL's representatives suggested that increases in coal prices in New South Wales meant that coal generators were now only slightly less expensive than gas generators. However, even using the most pessimistic assumptions on coal costs (see Table 3) and using AGL's estimate of gas generation costs, i.e. $7.5/GJ, AGL Energy Limited (2014) shows that coal generation avoidable costs are far below (at least half) those of gas generation costs.

[15] The difference between the market clearing price the generators' bids multiplied by their production.

[16] It might instead be argued that inframarginal rents would be maximised by reducing production at peak periods, thus driving prices even higher here. However, this argument is

in 2017 for both Bayswater and Liddell, although in 2018 Bayswater reduced production by a large amount in all hours, more than off-setting slight increases in production at Liddell.

Figure 30. Percentage of time throughout the day coal is setting the price in New South Wales



By comparison, AGL's Loy Yang A plant increased production in the off-peak periods so as to be producing close to full capacity across the day after Hazelwood closed. This bidding strategy resulted in higher exports from Victoria to New South Wales during the low demand periods (to make up for lost production at Liddell and Bayswater), and ensured that Victoria effectively imported higher prices from New South Wales as long as the interconnector remained unconstrained as it most often was (see Figure 24).

This bidding strategy is not evident for the other New South Wales generators: Origin, Sunset Power and Energy Australia changed production in 2017 by an approximately uniform amount across all hours of the day (see Figure 8 to Figure 10).[17]

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susceptible to the trade-off between higher prices and lower volumes. Since there is plentiful similarly priced gas and hydro plants to meet demands during the daily peak periods, we suggest that the slope of the supply curve is shallow at this point on the supply curve for most days during the daily peak periods. This means that reducing coal production during these peak periods will have little impact on market prices, and so this will not compensate for the consequential lost production. So, the common strategy to maximise inframarginal rent is in fact not necessarily to reduce production during the daily peak periods.

[17] Of itself however, this does not mean that these generators did not also exert market power, but rather if they did, they did it less optimally than AGL.

While the hourly production pattern is consistent with the proposition that AGL priced its production so as to maximise inframarginal rents, it might be argued that this rather reflected a scarcity of coal supply reflected in higher generators offers in order to ensure that production respected those coal constraints. If an argument of market power is to be sustained, it is necessary to be sure that such coal supply constraint did not exist.

3.3.1 Do coal constraints explain generator prices in the electricity market?

In submissions to the ACCC (see for example (AGL Energy Limited, 2017)) , and evidence reported by the Australian Energy Regulator (see (Australian Energy Regulator, 2017)) and the New South Wales Government Chief Scientist and Engineer (see (New South Wales Government Chief Scientist and Engineer, 2017)), the New South Wales generators described coal access constraints that they said limited their ability to increase production in order to respond to the withdrawal of capacity from Hazelwood. We examine this here distinguishing AGL from its peers considering the difference that AGL demonstrated in its pricing behaviour and consequent production relative to its peers. We identify four possibilities:

1. AGL suffered coal supply constraints but its competitors did not;
2. Neither AGL nor its competitors suffered coal supply constraints;
3. AGL did not suffer coal supply constraints but its competitors did;
4. Both AGL and its competitors suffered coal supply constraints.

For the first case, the conclusion would be that AGL did not exercise market power, but its competitors capitalised on AGL's coal constraints by colluding in the exercising market power to secure higher prices. The second case suggests the exercise of market power by AGL and its competitors: effectively collusion amongst all the generators. The third case suggests that AGL's competitors did not exercise market power but AGL did. The fourth case suggests that both AGL and its competitors suffered coal supply constraints and it is the consequential scarcity, not market power, that explains their higher offers.

AGL's competitors' possible coal supply constraints

Dealing first with AGL's competitors, in the case of Vales Point, no claim has been made publicly or in their communication with us about coal scarcity as influencing their pricing or production decisions since the closure of Hazelwood. Rather, it was suggested to us that their production after Hazelwood closure (4% more in 2017 than in 2016) reflected the maximum continuous operation of their plant given the constraints of their particular boilers. We have no basis to contest this and note that even a 10% increase in annual capacity factor (to 80%) would have translated into just 0.8 TWh per year of additional production. At 1.5% of New South Wales coal production in 2017, increasing Vales Point's production by 10% is unlikely to have had a significant impact on prices.

In the case of Energy Australia's Mount Piper Power Station, there were documented constraints (see (Energy Australia, 2017)) relating to their continued access to coal at the Springvale mine, its sole coal supply was to Mount Piper. This constraint was partially resolved in September 2017 and production at Mount Piper increased by 12% in 2018 compared to 2017, to a 72% annual capacity factor. We have no basis to reject Energy Australia's explanation of the impact of its Springvale constraints and note that, like Vales Point, increasing production at Mount Piper (a comparably sized plant) is not, on its own, likely to have had a significant enduring impact on prices.

In the case of Origin Energy's Eraring power station, in its public submissions, Origin referred to coal transport limitations in expanding production at Eraring more quickly than it had. Comparing 2017 and 2016, production at Eraring increased production by 38% in 2017 compared to 2016 or by 37% comparing 2017 to the average from 2011 to 2016, to a 70% capacity factor in 2017. We have no basis to contest Origin's claims, but note that a further 10% increase in Eraring production – which would equal around 6% of New South Wales total coal generation – could have been expected to have a meaningful influence on New South Wales prices.

On this basis we do not have compelling evidence to suggest that AGL's competitors could have substantially increased production after Hazelwood closed. However information asymmetry precludes a deeper analysis here, and we suggest it is appropriate to leave open the possibility that even if, individually, AGL's competitors might not have been able to greatly increase production, collectively this might have been possible. If this would have had a large impact on prices, they would not have had an incentive to increase production. Therefore at this point we conclude in favour of either possibilities Three and Four, rather than One or Two, and now turn to the question of coal supply constraints suffered by AGL.

AGL's possible coal supply constraints

In the redacted publicly available submission to the ACCC in September 2017 (see (AGL Energy Limited, 2017) AGL explained that since October 2016 (shortly before Hazelwood's closure was publicly announced), AGL priced Bayswater and Liddell output in order to reflect coal constraints. AGL attributed these constraints to extreme heat for a few days in February, coal conveyor breakdowns, possible industrial relations action, normal scheduled rail operator outages, contractual disputes, bushfires, lower than expected delivery performance and higher coal prices. As a result of these factors, AGL suggested that at September 2017 its coal stockpile "*is at the lower end of AGL's preferred envelope of operation coming into summer*". Assessment of AGL's claim that Bayswater and Liddell pricing reflects coal supply constraints needs to assess this explanation.

The first and last claims do not explain coal supply constraints. With respect to the first, Bayswater and Liddell production was unexceptional in February 2017. We discuss coal prices later. Without access to the confidential information provided to the AER and ACCC, it is not possible to assess AGL's claims. However, other evidence does not support the claim of supply constraints:

- Firstly, in the information AGL provided to investors in the Entitlement Offer (AGL Energy Limited, 2014) to fund its acquisition of these power stations in 2014, AGL contrasted the superior coal supply position of Bayswater and Liddell compared to their coastal competitors (Eraring and Vales Point). In particular it pointed to Bayswater and Liddell's access to multiple, low cost coal supply sources (so AGL was not captive to any mine/supplier like some of its competitors). Also AGL said they had access to significant coal delivery infrastructure (23 Mtpa unloader capacity – enough to handle twice its annual contracted coal demand in 2017), three conveyors and direct connection to the rail network. By contrast AGL said the coastal generators suffered from underground mines and that large-scale rail deliveries would require substantial rail-loop and coal unloader upgrades. Yet despite these disadvantages, Eraring increased its production by more than a third after Hazelwood closed, while AGL's power stations decreased production by 7% the year after Hazelwood closed (compared to the previous year, or 10% compared to the average of the previous 7 years).

- Second, reports by authorities have not verified AGL's claims. The AER verified AGL's public statements on its coal stockpiles but went no further. The ACCC did not opine on AGL's claims and instead concluded in its inquiry, as noted earlier, that higher wholesale prices are attributable to "*a subtle and sustained 'lift' in prices that can be attributed in part to a lack of competitive constraint*". The New South Wales Chief Scientist and Engineer's report noted advice from the Australian Energy Market Operator that in aggregate, production from New South Wales coal generation would be able to replace production lost from Hazelwood, yet in the event New South Wales coal generators only replaced 40% of the production lost from Hazelwood in the year after closure and even less in the following year. While acknowledging what she had been told by the generators, the Chief Scientist and Engineer went no further than to recommend greater transparency of coal production and stockpile data.
- Third, in its testimony to the Select Committee on Electricity Demand and Prices, AGL's two representatives did not at any point refer to coal supply constraints to explain why Bayswater or Liddell's prices had increased. Instead they attributed higher electricity prices entirely to higher coal prices. Similarly, AGL's annual reports to its shareholders and its briefings to its investors make no mention of coal supply constraints having constrained their operations. A supply constraint that so severely curtailed AGL's operations that it required them to double the price of their production, should surely have been reported to investors.
- Fourth AGL's production at the sum of its Bayswater and Liddell plants was even lower in 2018 than 2017. The data and explanation that AGL provided to the ACCC sought only to explain its bids up to September/October 2017. AGL

has provided no evidence or argument to suggest that coal supply constraints continued after this date and yet production was even lower in 2018 than 2017.

In summary, we suggest that Origin Energy and Energy Australia's arguments on coal supply constraints are, within the scope of this study, difficult to refute while AGL's claims that coal supply constraints explain their pricing of Bayswater and Liddell output since Hazelwood closed, do not seem plausible.

3.3.2 Do higher coal prices explain higher generator prices?

Both before and since Hazelwood closed, the spot price of coal traded at the port of Newcastle increased, although over the last year it has declined. Some welfare economists might argue that an assessment of market power should use the spot price of coal in the assessment of generators' fuel costs. The relationship between the prices that the NSW generators pay for coal and the spot price of coal at Newcastle is not known publicly. The Pearson Product Moment Coefficient of the correlation between the New South Wales electricity prices (when NSW coal generators set spot electricity prices in New South Wales) and coal spot prices (based on Indexmundi's Newcastle coal spot market index) ranges between 0.19 and 0.32 between 2016 and 2018. This suggests that generators did not price their production in the electricity spot market in a way that reflected changes in Newcastle spot coal prices. This is no surprise. The combination of the dominance of long-term coal contracts plus logistical and transport constraints in getting coal from mines that feed the NSW generators to the Newcastle port means that the NSW Newcastle spot price is clearly not the marginal price of coal to any of the NSW generators. Taking account of transport and logistical challenges, it is safe to assume however that the price of a marginal tonne of coal to any of the NSW generators is likely to be inferior to the Newcastle spot price of coal. Quite what the relationship between marginal and average prices are for any of the NSW generators is not publicly known and no doubt even for the generators themselves, the marginal cost of coal at any point of time is not objectively knowable, since it will depend on the details of their complex supply contracts and their historic and projected coal consumption. We note that the ACCC concluded that average coal costs for New South Wales generators increased by about 7% between 2016 and 2017, taking into account the circa 30% increase in average annual Newcastle spot coal prices between those years.

To get a sense of the impact of different coal price assumptions on electricity production costs, Table 3 below quantifies New South Wales generators' variable electricity production (fuel) costs and compares them to the spot prices received by the generators in 2017.

Table 3. Electricity production costs using various estimates of coal prices for generators in New South Wales[18]

	Bayswater	**Eraring**	**Liddell**	**Mt Piper**	**Vales Point**
Average price received ($/MWh) when setting spot prices in NSW in 2017	$86	$ 77	$107	$78	$85
Production cost ($/MWh) assuming average Indexmundi Coal Spot Price in 2017	$48	$48	$51	$47	$49
Production cost ($/MWh) using Wood Mackenzie coal prices in 2016	$14	$22	$15	$22	$22
Production cost ($/MWh) using AGL Entitlement Issue coal price estimates in 2017	$13	$25	$14	$24	$24

The table shows that even assuming hypothetically that all coal generation is priced as if coal was purchased at Newcastle spot prices, this still leaves 40%-60% headroom between the prices that the generators offered their output to the market at (when they were setting the New South Wales spot electricity prices) and the variable (fuel) cost of production. The gap is significantly larger if we use the coal prices estimated by Wood Mackenzie or that AGL used in its Entitlement Issue presentation. In its investor presentations to accompany its financial results, AGL cites Wood MacKenzie to explain coal costs in New South Wales, and so we presume they suggest this as a plausible estimate of their and their competitors' coal costs. In discussion with us, neither Origin Energy, nor Energy Australia nor Sunset Power suggested that coal prices explained their offer prices in 2017 after Hazelwood closed. By contrast AGL's representatives to the New South Wales Select Committee on Electricity Demand and Prices explained that the prices offered by its generators in New South Wales were

[18] Sources: https://www.indexmundi.com/commodities/?commodity=coal-australian&months=60&currency=aud (AGL Energy Limited, 2014), (Wood McKenzie, 2016).

explained by their coal prices, and specifically the requirement to supplement its contracted purchases with higher priced spot market coal purchases.[19]

Using data in AGL's Entitlement Issue on contracted coal volumes in 2017 (11 mtpa), we estimate that AGL's New South Wales aggregate Bayswater plus Liddell production in 2017 of 24.94 TWh was met through contracted coal purchases, leaving only changes in inventory to account for short-term coal purchases. In other words, AGL's fuel cost of production using the data on its actual 2017 production and its Entitlement Offer data on contracted purchase volumes, delivers average variable production costs of $13-$14/MWh in 2017. This price is likely to be a little higher in 2018 since lower 2018 production will have been more than offset by lower 2018 contracted deliveries (as specified in the Entitlement Offer), meaning some level of spot market purchases to make up the shortfall. However, the gap between 2018 and 2017 coal prices is likely to be small, so we conclude from this that for both years, AGL's coal prices cannot explain the prices at which they offered Bayswater or Liddell production into the NEM. Further evidence of this can be found in AGL's 2018 Financial Report where it reports annual fuel costs (for electricity and gas together) of $21.7/MWh. This is a blended average of AGL's black and brown coal and gas costs. Gas is very much more expensive (and prices have increased much more quickly than black coal), while brown coal is cheaper than black coal. Taken together and considering the dominance of AGL's black coal purchases, AGL's black coal-only average price in 2018 is likely to be less than $21.7/MWh.

3.3.3 Did contract markets affect generator incentives to exercise market power?

Generators and retailers are able to manage the risks they face through uncertain and volatile spot prices by entering into financial contracts that swap spot prices for fixed prices. Since the wholesale spot market is centrally settled, these contracts are effectively contracts for the difference between the strike price and the spot prices. One of the most widely traded contracts is a "Base load" contract for the purchase of

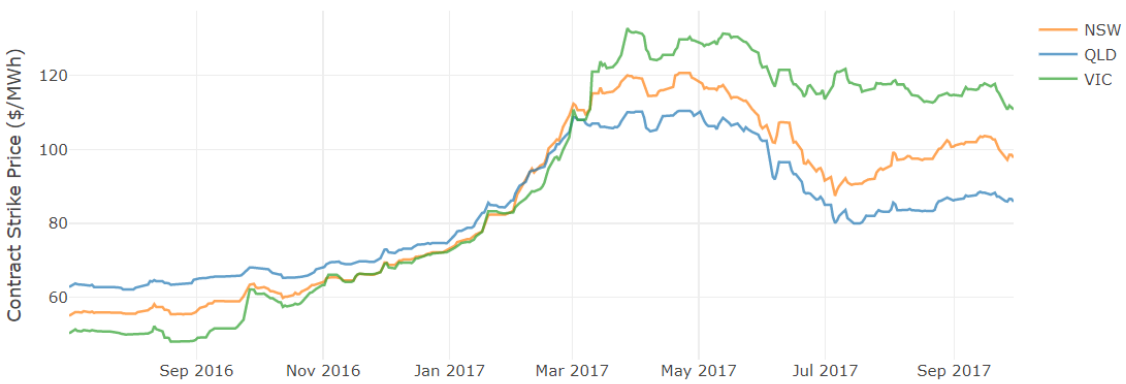
[19] Actually AGL's investor presentations show its contracted coal purchases covered their full New South Wales production in FY 2017 and spot market coal purchases equivalent to around 4% of contract purchases were used to replenish stockpiles. In FY 2018 spot purchases replenished stockpiles and made up for a very small gap between contract coal purchases and production.

1 MW for each hour for the year, and is traded on the Australian Stock Exchange. The contracts exist by quarter, calendar year or financial year.

We examined the prices and trades on the Australian Stock Exchange of the New South Wales, Victoria and Queensland Base Load contract for the 2017/2018 financial year (by far the most liquid base load contract), starting one year before the start of the financial year to which that contract relates and ending at the end of the first quarter of the financial year (after which the ASX no longer conducts trade in the contract).

This analysis finds weighted average prices (based on ASX-settled trades) of $65/MWh, $115/MWh and $79/MWh for New South Wales, Victoria and Queensland on total traded volume of 27,490, 37,978 and 26,700 contracts. Figure 31 below charts the contract prices over the relevant time period. It shows a slight up-tick when Hazelwood's closure was announced, followed by a gradual rise until the start of the year, then a rapid rise up to the end of the first quarter's trade, and then a decline until trade in the contract ceased at the end of September 2017.

Figure 31. Contract strike price, New South Wales 2017 calendar year base load contract



In principle, leaving other factors to one side, a generator that has contracted its output has an incentive to sell its output in the spot market at its avoidable costs, regardless of whatever it expects spot prices might be. In practice, a contracted generator's spot market bidding incentives are likely to be found through consideration of the other factors left to one side. Specifically, a generator-retailer that is long generation (more contracted generation than contracted load) may be motivated to push spot prices up even if this might result in losses on its contract position if such losses are more than made up for additional spot market income (from the uncontracted portion of production) and the pain high spot prices will inflict on competing retailers who are unhedged and hence exposed to those high spot prices. In this way, spot market outcomes can condition contract market outcomes to suit the position of the dominant sellers in the contract market (who are also the dominant sellers in the spot market). Sophisticated market participants are also likely to consider profitability across multiple years: losses on a contract position in one year might be more than made-up by higher contract prices in later years if buyers are conditioned by previous years' contract market outcomes.

Spot market outcomes are not just endogenous to contract market outcomes as the AER suggests. It works the other way around as well: the contract market will be affected by the same oligopoly competition issues that affect the spot market. This is particularly so since the dominant sellers of contracts are the same participants that are the dominant sellers in the spot market, and by pushing prices up in contract markets these participants are able to condition expectations (and signal to their competitors) in the spot market, and thus achieve the same outcomes in contract markets that they can achieve in spot markets.

The Australian Energy Regulator, recognising the incentive on contracted producers to offer their production in the spot market at their production costs (leaving other factors to one side), say that it cannot conclude on the incentive to exercise market power without knowing generators' contract positions (see (Australian Energy Regulator, 2018b)). However, as noted above, this logic is fallible to the other factors left to one side and, as we suggested, it is in these other factors that the truth of the incentives on producers to exercise market power in the spot market is to be found. We suggest the complexity of the issues here (for example how is a regulator to understand the time horizon that traders will consider in contract and spot market trading) means that the insight that the AER is seeking on generator incentives to exercise market power by knowing their contract positions, is not obtainable.

An alternative, possibly more useful, way to understand contract prices and their relationship to spot prices is to observe the way spot market outcomes are transmitted to contract prices. Figure 31 shows a slight up-tick in the 2017 contract price when the

Hazelwood closure was announced on 3 October 2016. This reflects, we suggest, market participant perceptions that closure should not be likely to have a significant impact on spot prices. The contract volume data shows trading volumes accelerated to a peak after closure, at these prices. However as AGL progressively re-priced Bayswater and Liddell production after the Hazelwood closure was announced, and as other generators followed suit to a more moderate extent (see Figure 6 to Figure 10), contract prices rose. They reached their peak a month before the contracts entered into effect and when New South Wales generator re-pricing was most severe. This suggests that the contract market has transmitted expectations based on the most recent spot market outcomes, and that knowledge of market participant contract market positions (if it could be obtained and we doubt this would be possible anyway) is unlikely to shed light on the incentives for producers to bid their avoidable costs in the spot market.

3.4 Summary

The hypothesis we test here based on the model of oligopolistic competition set out in Woerman (2018b) specified an optimum mark-up rule: that generators seek to offer their production to the market in a way that maximises inframarginal rents and when the firm's competitors are least able to respond to higher prices by increasing their own production in response to those higher prices. The timing of the changes of AGL's spot market bids for production by Bayswater and Liddell, the level of those revised prices and the consequent hourly pattern of production since Hazelwood closed, we suggest is consistent with the optimum mark-up rule. We suggest this on the basis of the coal supply and operational constraints of AGL's competitors. It is the existence of these constraints that undermined AGL's competitors' ability to respond to the higher prices that AGL's bidding delivered. By contrast we suggest AGL's arguments on its own coal supply constraints do not seem plausible. We also suggest that AGL's bidding is consistent with the optimum mark-up rule on the basis that the hourly pattern of those bids, particularly in 2017, is consistent with the proposition that AGL sought to maximise inframarginal rents. Thus we conclude that the main factor explaining the price rises in the NEM following the closure of Hazelwood is AGL's exercise of market power at its Bayswater and Liddell power stations.

4 Implications

Here we examine the implications for producers, consumers, the environment and efficiency, of the exercise of the market power analysed in this paper.

Producers' profits

An estimate of the impact of higher prices on producer profits can be obtained by analysing AGL's annual accounts. Around 85% of AGL's 43 TWh annual sales is produced by the coal-fired generators that it owns in Victoria and New South Wales. Analysis of AGL's Full Year Results Presentations and its Annual Financial Reports[20] finds that between the last full financial year before Hazelwood closed, to the first full financial year after it closed, AGL's wholesale Electricity Wholesale Gross Margin grew by $832 million (60%).[21]

Consumers

We calculate that in 2017 after Hazelwood closed, had coal generators in the NEM received the 2016 weighted average price[22] for their 2017 production, the aggregate annual payment from the spot market to coal generators in the NEM would have been $3.47 billion lower than it actually was.[23] A test of the plausibility of this estimate is

[20] Available from https://www.agl.com.au/about-agl/investors

[21] Over the same period, AGL's Electricity Revenues grew by $947 million (16%). The consequent growth in its Wholesale Gross Margin (60%) is evidence of AGL's ability to translate revenue increases into profit increases. This ability is attributable to its access to low cost coal in Victoria and New South Wales. Electricity Business Earnings before Interest and Tax grew by $789 million (42%).

[22] Calculated when coal generators set the spot price in each NEM region.

[23] It might be argued that this estimate is unrealistically high since we have not taken account of the fact that Hazelwood's withdrawal means that demand would have cleared further up the pre-closure supply curve after it closed. Conversely it might be argued that this estimate is too low since we have not adjusted for the decline in aggregate demand in 2017 relative to 2016 and we have not included Tasmania. More importantly than both of these, we have not accounted for the knock-on impact of higher prices from coal-fired producers in providing a higher floor for the prices offered by hydro and gas generators as shown for NSW in Figure 13. It should also be recognised that this analysis assumes that spot market outcomes are ultimately reflected in prices paid by consumers. The analysis in this section shows that this is a plausible assumption. In addition, it should be noted that this estimate reflects changes in the average demand (when coal was setting prices) between 2016 and 2017 and also changes in the proportion of the time that coal generators set spot prices. The adjustment for the change

to extrapolate to the full market, the difference in the electricity revenues that AGL achieved before and after Hazelwood closed – $947 million. Since AGL sells approximately 29% of all electricity in the NEM, this implies the aggregate market impact would be around 3.5 times AGL's revenue increase, i.e. $3.3 billion.

The previous section suggested that contract markets have been influenced by spot market outcomes and in this way spot market outcomes have been transmitted to other retailers and, to varying extents, on to consumers. In the case of AGL, as discussed above, it is evident that AGL has been successful in passing on higher wholesale market prices to consumers since the increase in the Gross Margin (i.e. Earnings before Interest and Tax) of its Wholesale Electricity plus Consumer Electricity Plus Business Electricity businesses was $789 million or 95% of the change in its Wholesale Electricity Gross margin comparing the last calendar year before Hazelwood closed to the first calendar year after it closed. Clearly AGL has been able to substantially pass higher wholesale costs through to its customers. We suggest that AGL's ability to pass higher wholesale prices through to its customers is not any different to that of any of the other large retailers,[24] and on this basis we conclude that across the industry the exercise of market power in wholesale markets has been substantially transmitted to consumers in the form of higher prices.

Environment

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in demand makes very little difference ($16m), whereas adjustment for the percentage of time that coal generation was at the margin makes a bigger difference ($525m), so that the estimate of the impact on consumers reduces from $3.47 billion to $2.94 billion once we adjust for this. Coal-fired generators set the price less frequently in 2017 than 2016, explained in large part by the fact that it was much more expensive and thus other competing generators at border of the supply stack with coal (i.e. gas and hydro) set prices more frequently in 2017 than 2016. The adjustment means that we end up excluding the impact of the exercise of market power attributable to those times that coal was replaced by competing technologies. On balance we do not consider that this would be appropriate and so prefer the unadjusted $3.47 billion estimate.

[24] Specifically AGL's annual report does not suggest it lost customers after putting it prices up. Analysis of Energy Australia's accounts show 94% pass-through over the comparable periods (wholesale gross margins increased by $616m compared to wholesale plus retail gross margin increases of $581m). The information in Origin Energy's account do not allow for a comparison along these lines, but in its 2018 Annual Report Origin Energy notes that higher wholesale prices were passed through to its customers (p. 20). However, the smaller retailers, having disproportionately more of the price sensitive customers than the larger retailers, are likely to be less successful in passing the full increase in their wholesale costs to their customers.

From the perspective of electricity sector greenhouse gas emissions, we do not expect that the exercise of market power will have had a significant impact in the short term, since in the short term demand is inelastic to price, and the other New South Wales generators that compensated for foregone production from Bayswater and Liddell (i.e. Eraring, Vales Point and Mt Piper) are comparably efficient in turning coal into electricity. However the impact of the exercise of market power on higher prices could have a meaningful environmental impact in the longer term. On the one hand, it might be argued that higher prices associated with the exercise of market power will reduce emissions by stimulating more rapid expansion of wind and solar generation in response to those higher prices. On the other hand, it might be argued that high prices will increase emissions by stimulating investment to extend the life of the remaining coal generators on account of their higher profitability. It might also be argued that higher prices will undermine the transition to low emission generation since it makes the remaining coal-fired generators more valuable, and hence a firmer policy response (and greater expense) will be needed to achieve the objective of rapidly reducing greenhouse gas emissions from the electricity sector.

Efficiency

From an operational efficiency perspective, we have not attempted to calculate the impact of the exercise of market power, but we estimate non-trivial efficiency impacts since production from by far the cheapest black coal generators (Bayswater and Liddell) was replaced by more expensive black coal generators in New South Wales and Queensland. Efficiency will also be detrimentally affected in the longer term through foregone consumption (demand is elastic to price in the longer term) and by stimulating inefficient capital replacement in response to market prices that are inflated through contrived rather than genuine supply scarcity.

5 Conclusions

This research finds that prices in the wholesale electricity market since the closure of Hazelwood reflect the exercise of market power in those periods in which coal-fired generators set prices in each region of the market. This has had a large impact on consumers and producers, and is likely also to have a large impact on economic efficiency and the environment. The conclusions raise obvious concerns about supply-side market concentration and also about the design, operation and oversight of the wholesale market. The importance of these impacts, not least in the context of further coal generation closure in future, merits serious consideration and policy response.

It may be the case that deeper examination of AGL's procurement of coal for its Bayswater and Liddell power stations finds a higher level of constraint than we have concluded here. If so, this should shift the focus of policy consideration to the way that coal supply constraints in New South Wales are priced in generators' offers into the electricity market, and the extent to which electricity producers in New South Wales and elsewhere are able to profit from those constraints and so may be reticent in resolving them.

It may also be the case that deeper examination of the coal supply issues affecting Mount Piper and Eraring power stations and the operational issues affecting Vales Point finds that they are less constraining than we have concluded here. If so, this raises the prospect that the New South Wales generators may have colluded in the exercise of market power.

Appendix A: Generator spot market offers for coal generators in Victoria and Queensland

Figure 32. Loy Yang A Power Station (Victoria)

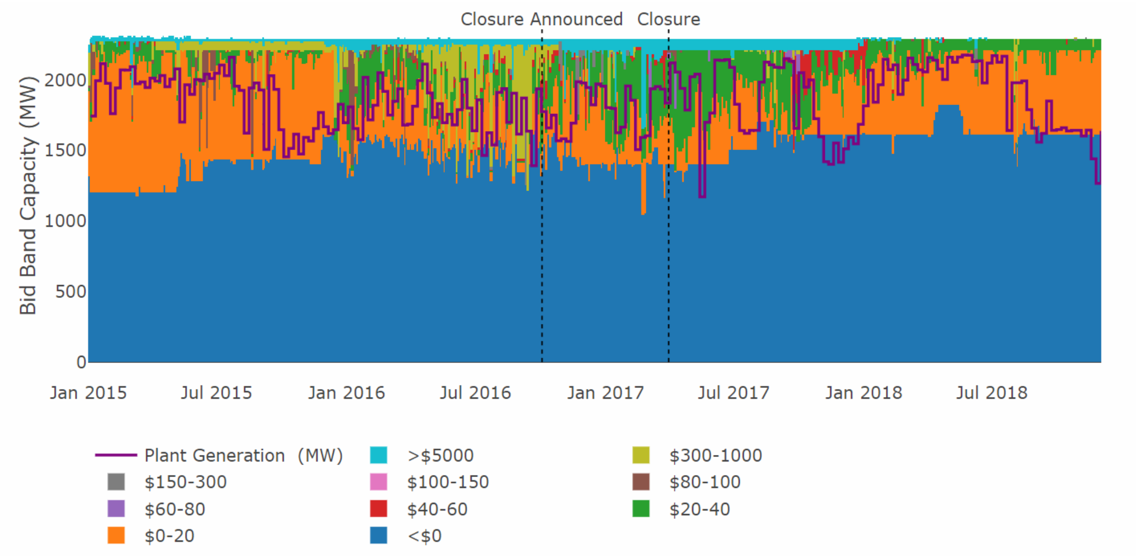


Figure 33. Loy Yang B Power Station (Victoria)

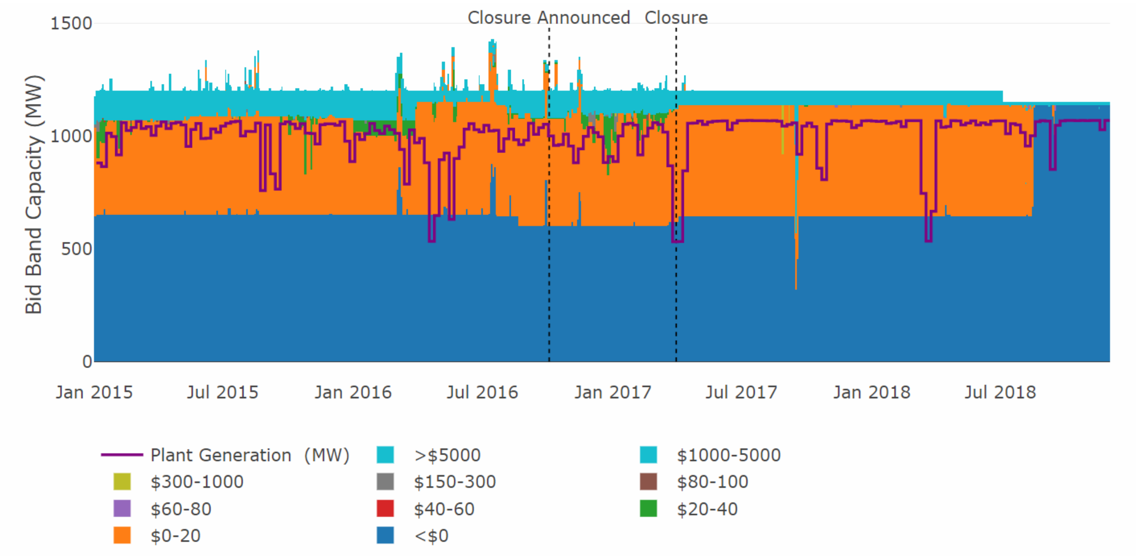


Figure 34. Yallourn 'W' Power Station (Victoria)

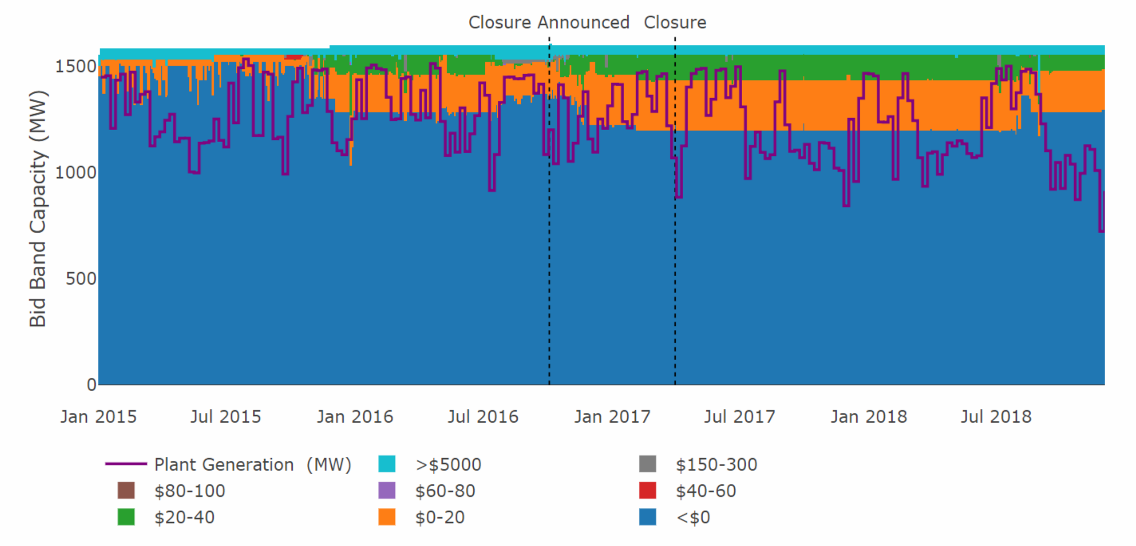


Figure 35. Hazelwood Power Station (Victoria)

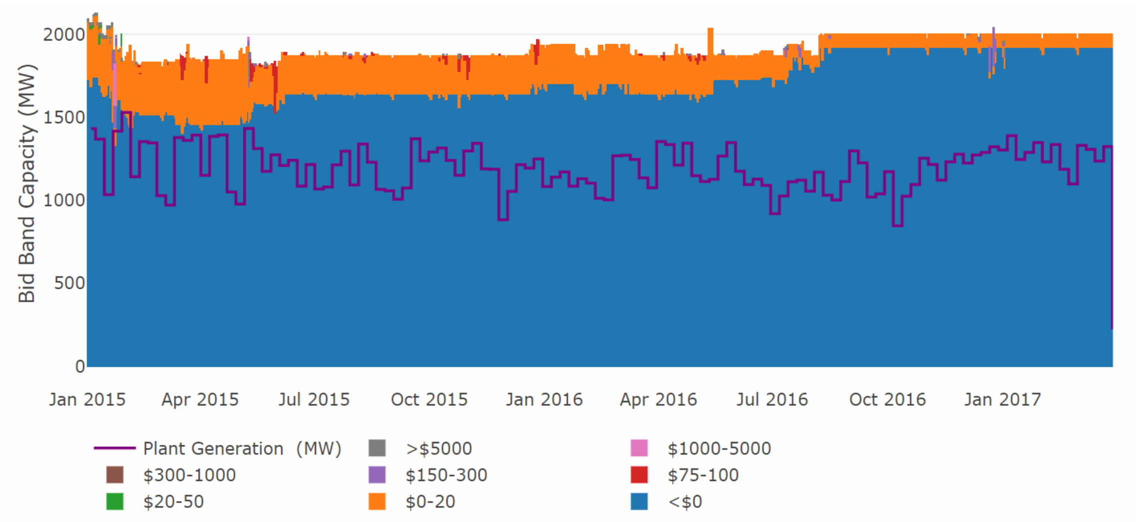


Figure 36. Callide C (Queensland)

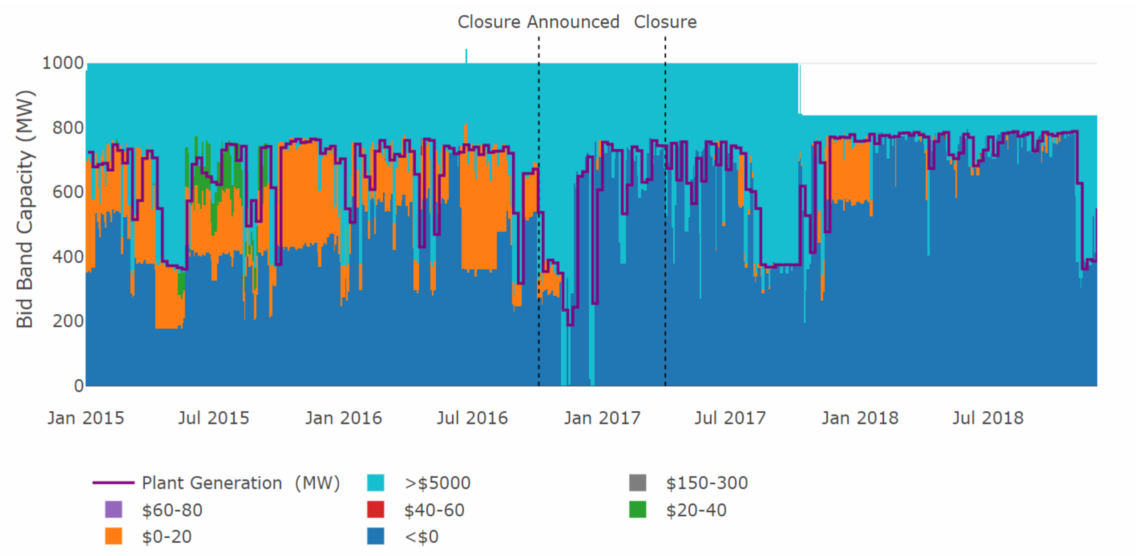


Figure 37. Gladstone Power Station (Queensland)

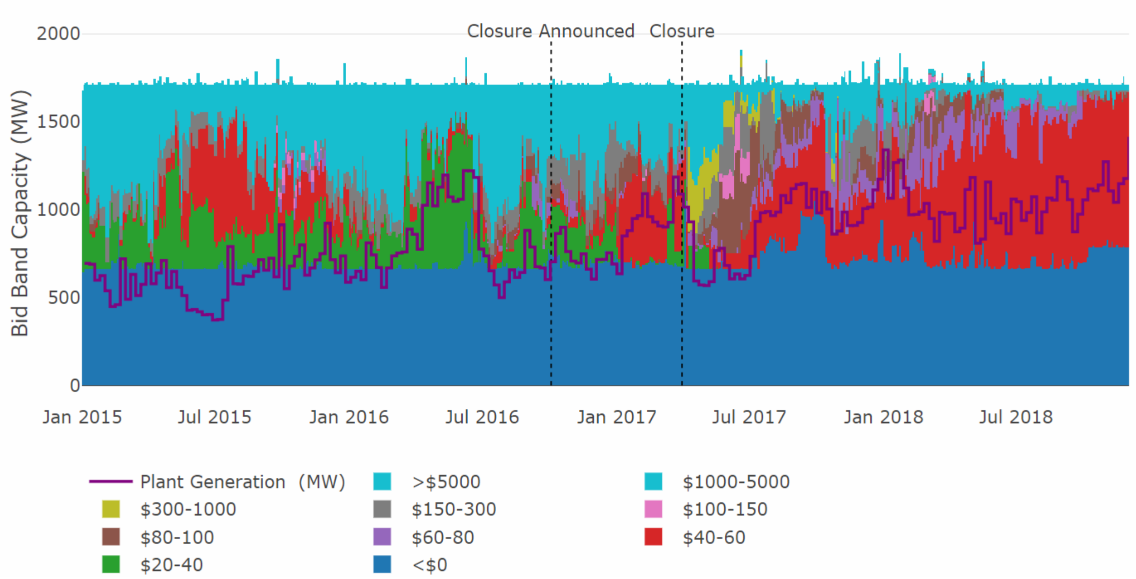


Figure 38. Kogan Creek Power Station (Queensland)

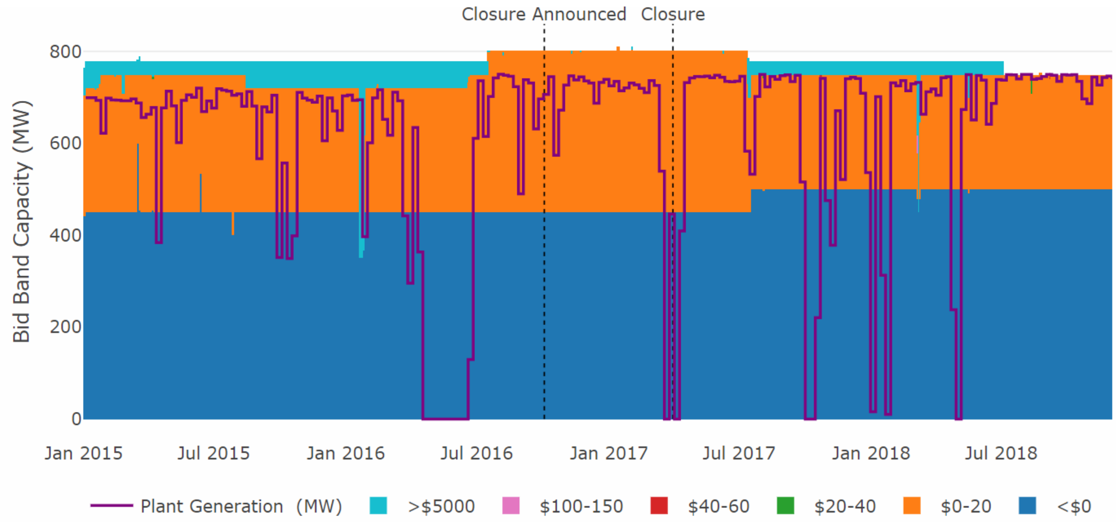


Figure 39. Millmerran Power Plant (Queensland)

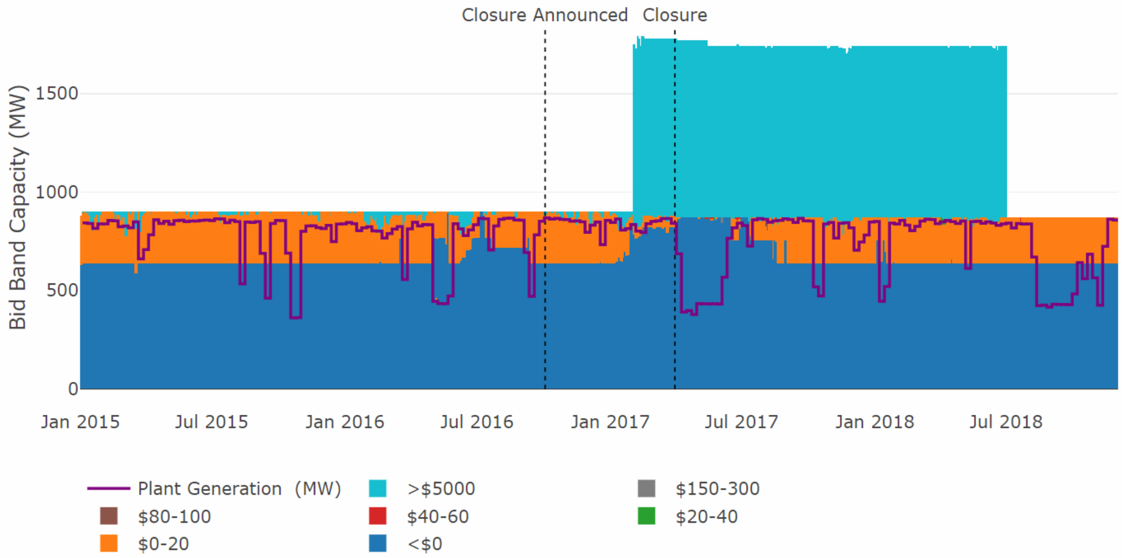


Figure 40. Stanwell Power Station (Queensland)

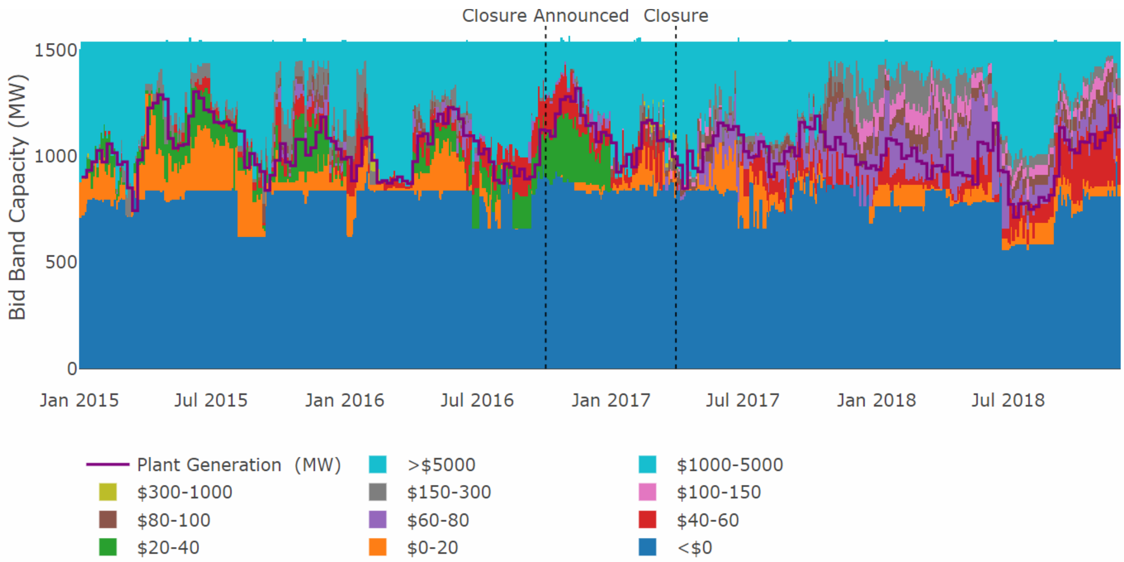


Figure 41. Tarong North Power Station (Queensland)

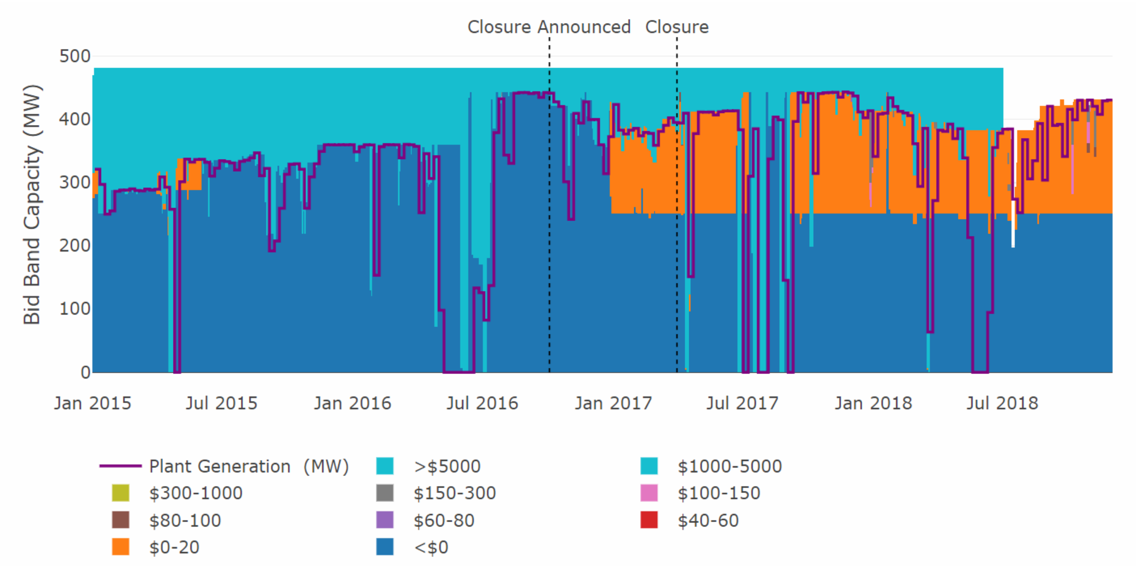
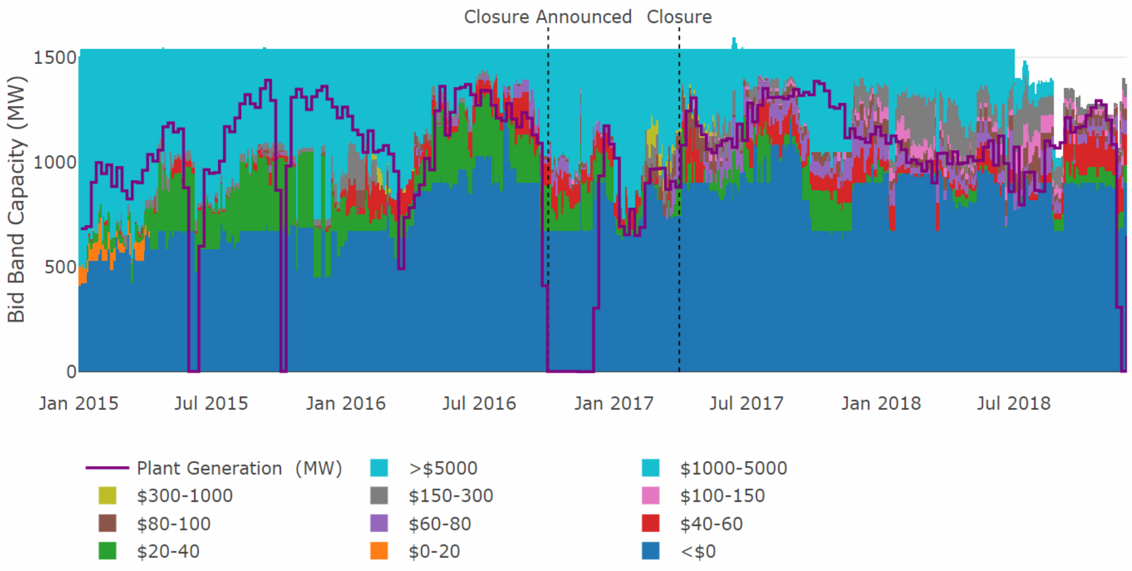


Figure 42. Tarong Power Station (Queensland)



Appendix B: Generator production for coal generators in Victoria and Queensland

Figure 43 to Figure 53 show the 5-minute daily mean profile and 10/90%probability of exceedance band for Victoria and Queensland coal generators.

Figure 43. Loy Yang A Power Station (Victoria)

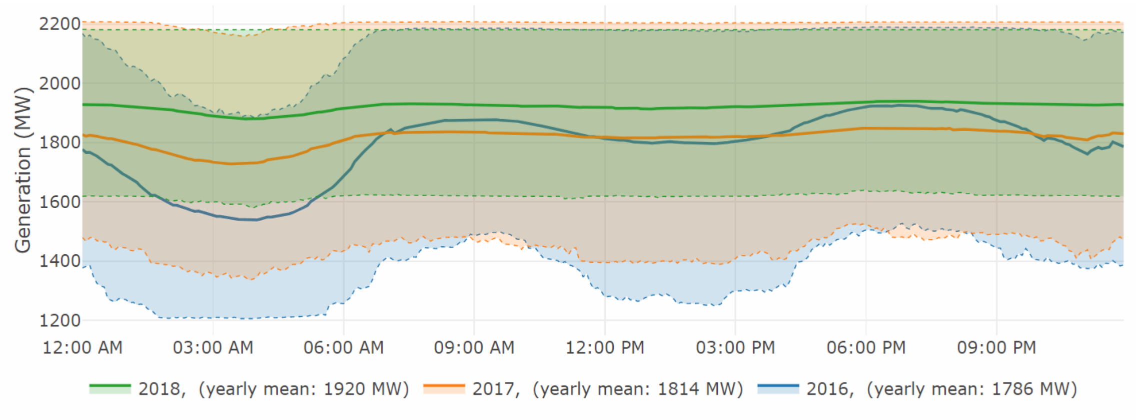


Figure 44. Loy Yang B Power Station (Victoria)

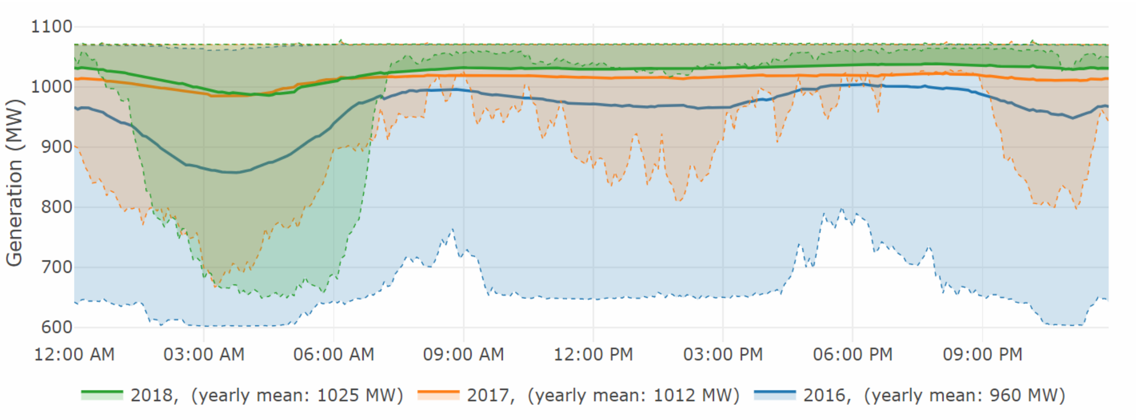


Figure 45. Yallourn 'W' Power Station (Victoria)

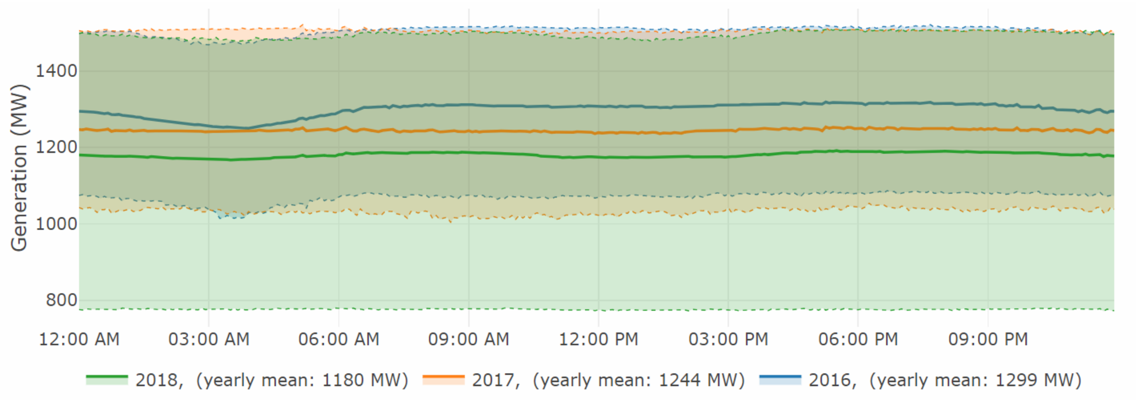


Figure 46. Hazelwood Power Station (Victoria)

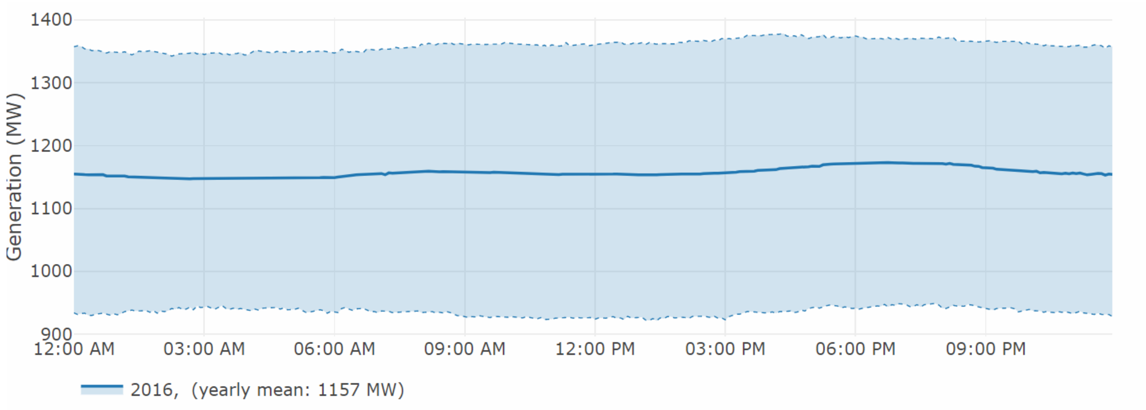


Figure 47. Callide C (Queensland)

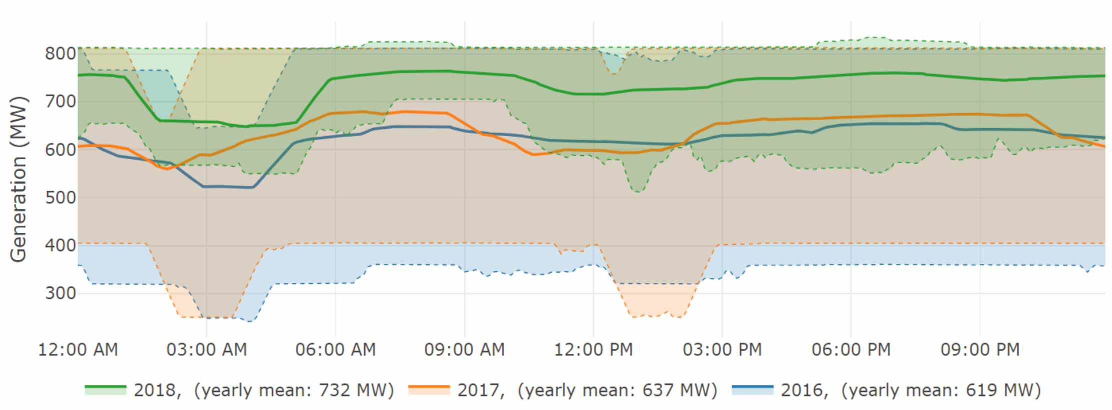


Figure 48. Gladstone Power Station (Queensland)

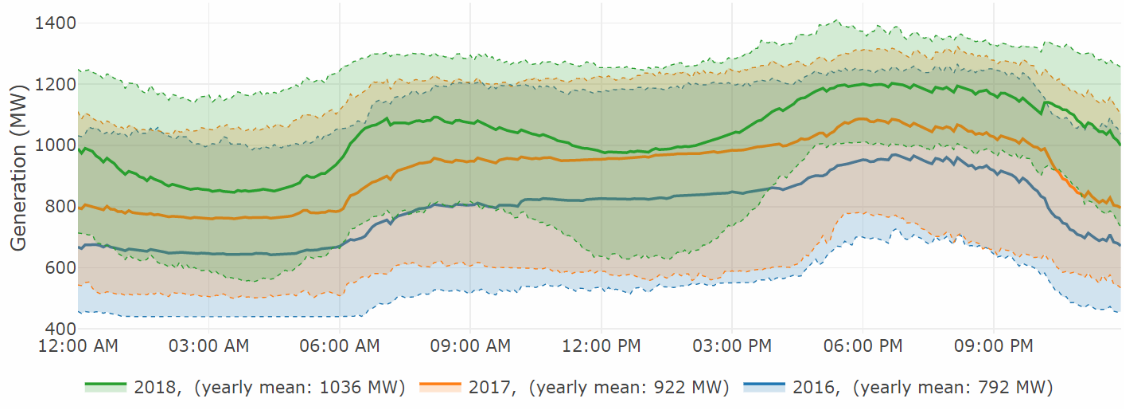


Figure 49. Kogan Creek Power Station (Queensland)

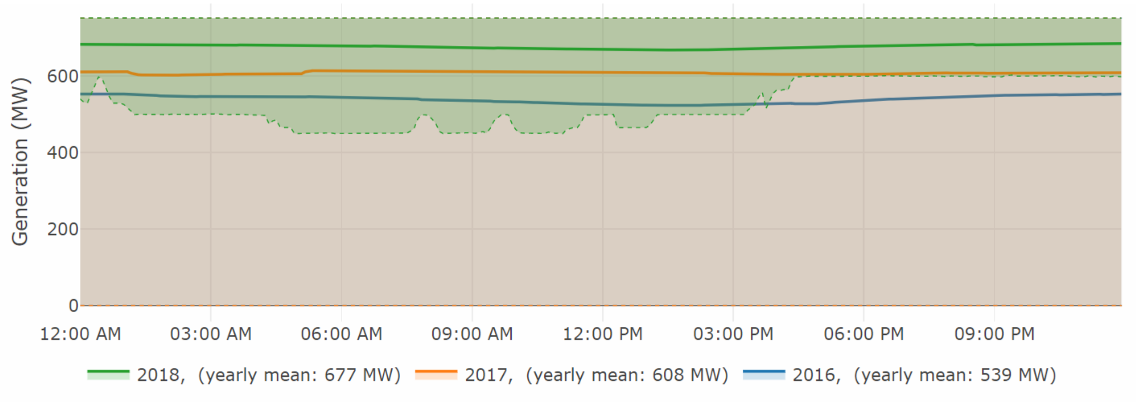


Figure 50. Millmerran Power Plant (Queensland)

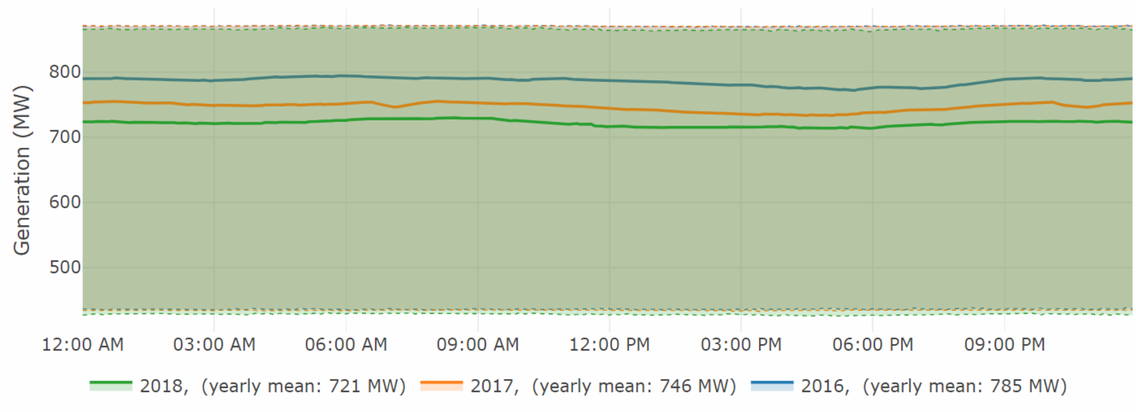


Figure 51. Stanwell Power Station (Queensland)

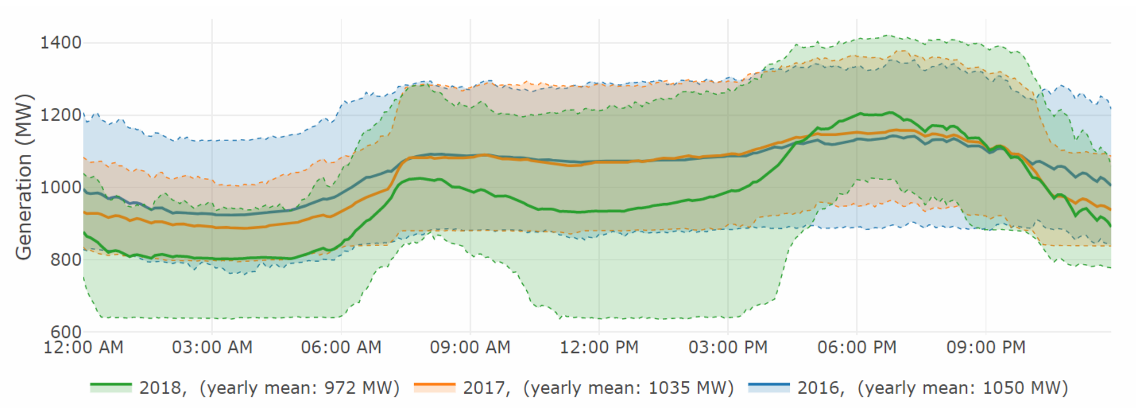


Figure 52. Tarong North Power Station (Queensland)

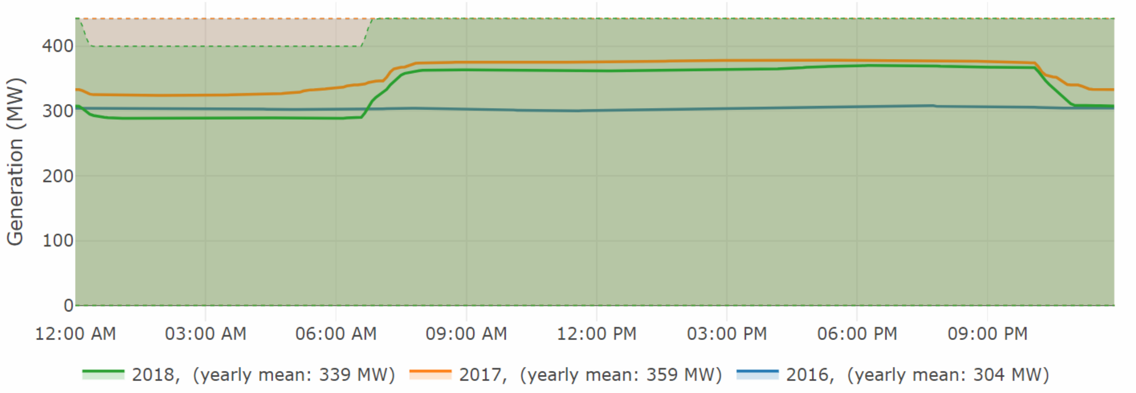
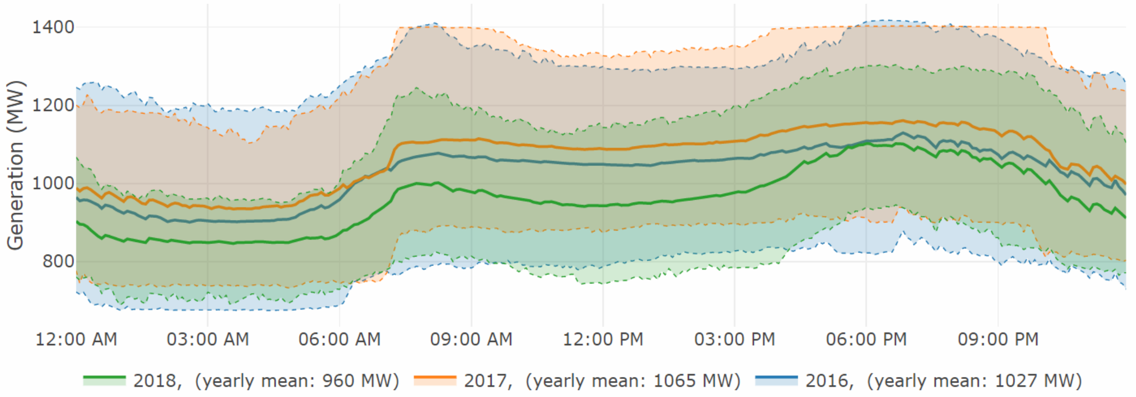


Figure 53. Tarong Power Station (Queensland)



References

ACCC (2014) ‘Statement of Issues AGL Energy Limited – proposed acquisition of the business and assets of Macquarie Generation’, (February), pp. 1–17.

Acil Allen Consulting (2014) *Emission Factors Report for AEMO*.

AGL Energy Limited (2014) *Macquarie Generation Acquisition: Presentation prepared in relation to a pro-rata accelerated renounceable entitlement offer*. Sydney, NSW.

AGL Energy Limited (2017) *New South Wales Coal Supply: A supplementary submission to the ACCC.* Sydney, NSW.

Australian Competition and Consumer Commission [ACCC] (2018) *Restoring electricity affordability and Australia's Competitive Advantage: Retail electricity pricing inquiry - Final Report*.

Australian Energy Markets Commission (2013) *FINAL RULE DETERMINATION Potential Generator Market Power in the NEM*. Sydney, NSW.

Australian Energy Regulator (2017) *NSW electricity market advice*. Melbourne.

Australian Energy Regulator (2018a) *AER electricity wholesale performance monitoring: Hazelwood advice*. Melbourne.

Australian Energy Regulator (2018b) ‘AER electricity wholesale performance monitoring’, (March).

Ball, A. *et al.* (2017) ‘Australian energy update 2017, Australian energy statistics’, (August). Available at: www.environment.gov.au.

Baumol, W. J. and Blinder, A. S. (1999) *Economics principles and policy*. 8th edn. Harcourt.

Biggar, D. (2011) *The Theory and Practice of the Exercise of Market Power in the Australian NEM, Aer*. Melbourne: Australian Competition and Consumer Commission. Available at: https://www.aemc.gov.au/sites/default/files/content/1b0947b4-930f-449a-be21-4cf009b2fe7a/AER-Attachment-1.PDF.

Borenstein, S. and Bushnell, J. B. (1999) ‘An empirical analysis of the potential for market power in California's electricity industry’, *Journal of Industrial Economics*, XLVII(3), pp. 285–324.

Borenstein, S., Bushnell, J. B. and Wolak, F. A. (2002) ‘Measuring Market Inefficiencies in California's Restructured Wholesale Electricity Market Measuring Market Inefficiencies in California's Restructured Wholesale Electricity Market’, *Source: The American Economic Review*, 92(5), pp. 1376–

1405. Available at: http://www.jstor.org/stable/3083255%5Cnhttp://about.jstor.org/terms.

Bushnell, B. J. B., Mansur, E. T. and Saravia, C. (2008) 'Vertical Arrangements , Market Structure , and Competition : An Analysis of Restructured US Electricity Markets', (2002), pp. 237–266.

Eeckhout, J. *et al.* (2017) *The Rise of Market Power and the Macroeconomic Implications*.

Energy Australia (2017) *Energy Australia calls for timely resolution to Mt Piper coal supply*.

Green, R. J. and Newbery, D. M. (1992) 'Competition in the British Electricity Spot Market', *Journal of Political Economy*, 100(5), pp. 929–953.

Hashmi, A. R. (2013) 'Competition and Innovation : the Inverted-U', 95(December), pp. 1653–1668.

Hortac, A. (2008) 'Understanding strategic bidding in multi-unit auctions : a case study of the Texas', 39(1), pp. 86–114.

Joskow, P. L. and Kohn, E. (2011) 'A Quantitative Analysis of Pricing Behavior in California's Wholesale Electricity Market During Summer 2000', *The Energy Journal*, 23(4), pp. 1–35. doi: 10.5547/issn0195-6574-ej-vol23-no4-1.

Klein, B. (1993) 'Market Power in Antitrust: Economic Analysis after Kodak', 3, pp. 43–92.

Levine, M. E. (2002) 'Price Discrimination without Market Power', *Yale Journal on Regulation*, 19(1), pp. 103–117. doi: 10.3868/s050-004-015-0003-8.

Mansur, E. T. (2004) *Environmental Regulation in Oligopoly Markets : A Study of Electricity Restructuring E*. 38. New York. Available at: https://ssrn.com/abstract=601366.

Mountain, B. and Percy, S. (2018) *Does renewable electricity generation reduce electricity prices ?* Melbourne. Available at: www.vepc.org.au/reports.

New South Wales Government Chief Scientist and Engineer (2017) *Final report from the Energy Security Taskforce*. Sydney, NSW.

Productivity Commission (2012) *Price Regulation of Airport Services, Report Number 19.* Canberra, ACT.

Ryan, N. (2017) *The Competitive Effects of Transmission Infrastructure in the Indian Electricity Market. Working Paper 23106, NBER Working Paper Series*.

Woerman, M. (2018a) *Market Size and Market Power : Evidence from the Texas Electricity Market*. 298. Berkeley, California. Available at: https://ei.haas.berkeley.edu/research/papers/WP298.pdf.

Woerman, M. (2018b) *Market Size and Market Power : Evidence from the Texas Electricity Market*. 298. Berkeley, California.

Wolfram, C. D. (1999) 'Measuring Duopoly Power in the British Electricity Spot Market', *American Economic Review*, 89(4), pp. 805–826. doi: 10.1257/aer.89.4.805.

Wood McKenzie (2016) *Coal cost projections. A report for the Australian Energy Market Operator*.