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NATIONAL ENERGY EMISSIONS AUDIT

National Energy Emissions Audit | Electricity Update

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A comprehensive, up-to-date indication of key electricity trends in Australia

Author | Hugh Saddler
Reviewer | Ben Elliston

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Level 1, Endeavour House, 1 Franklin St
Canberra, ACT 2601
Tel: (02) 61300530
Email: mail@tai.org.au
Website: www.tai.org.au

Introduction

Welcome to the September 2017 issue of the *NEEA Electricity Update*, the companion publication to the *National Energy Emissions Audit Report*. The *Electricity Update* is published monthly and presents data on electricity demand, electricity supply, and electricity generation emissions in the National Electricity Market (NEM). Notes on methodology are in the appendix.

This issue looks at the challenge of supplying peak demand in the NEM and why there are better options than extending the life of a 50 year old coal-fired power station with a long history of unpredictable breakdowns.

Key points

+ ***Liddell is part of the problem, not the solution***

A special analysis of peak demand in February 2017 shows that parts of the Liddell power station failed at the most important times for NSW peak load, along with gas generators Tallawarra and Colongra.

It is possible, though not certain, that after Liddell closes, supply shortfalls lasting only a few hours may occur in some, but not all years. In any case, AEMO finds that there will be no shortfalls if new renewable generation is built, additional to that already under construction. Implementation of smart demand response programs would be a far cheaper and less environmentally damaging way to meet such peaks than keeping Liddell open.

+ ***NEM electricity generation emissions down again***

Total emissions from electricity generation in the NEM fell again in the year to August 2017, for the second month in succession.

+ ***Brown coal generation continuing down, with Queensland black coal generators the main beneficiaries***

Supply trends reported in the August issue continued, with coal generation in Queensland and NSW both up, together with net exports from Queensland to NSW.

+ ***Wind generation sets a new 30 minute record peak in August***

August was another very strong month for total wind generation, which was only slightly lower than in July. On 16 August total wind generation across the NEM set a new record of 3,629 MW averaged across a 30 minute trading interval. The following day, all renewables, including rooftop solar, supplied over 31% of all electricity in the NEM.

+ ***Demand trends unchanged***

Total demand for electricity in both the NEM and WA in the year to August 2017 showed almost no change from a month earlier and past trends continued in each state.

Generation and emissions

Total annual emissions from electricity generation in the NEM fell by 0.9 Mt CO_2-e, equal to 0.5%, from July to August 2017 (see Figure 1), while total generation was almost unchanged for the fourth successive month. Lower emissions are a direct consequence of reduced supply from highly polluting brown coal generators, mainly due to the Hazelwood closure. The replacement energy has been provided by increased black coal generation in NSW and increased gas generation in Victoria and SA, both having much lower emissions intensity (Figure 2).

Figure 1

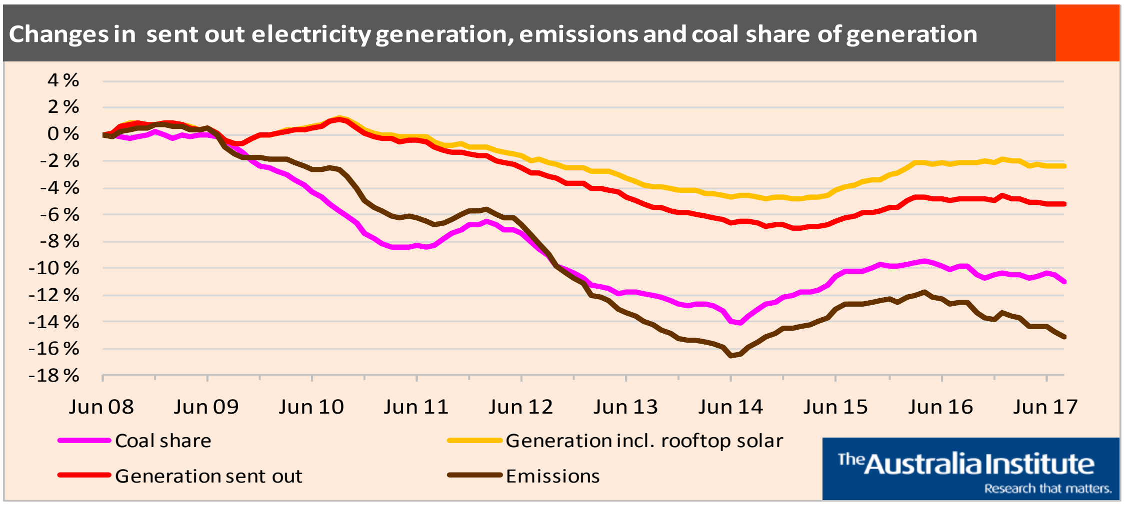


Figure 2

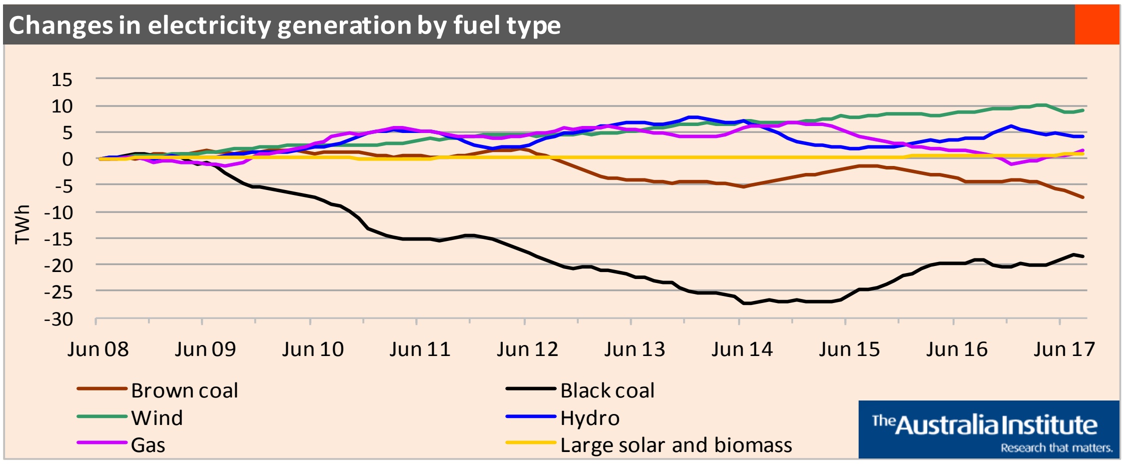


Figure 3

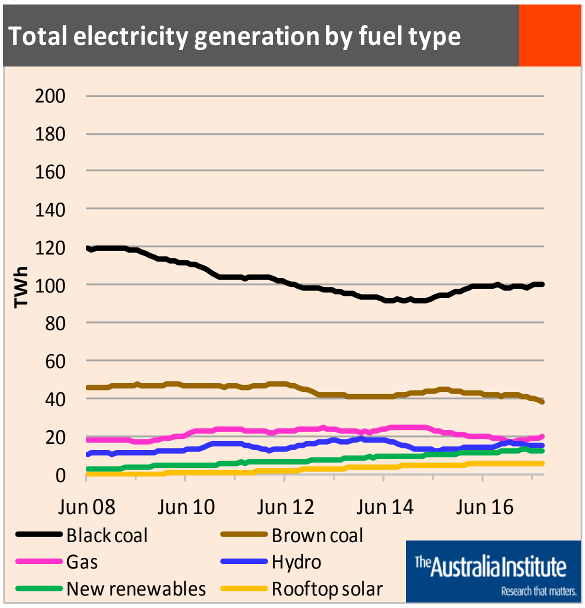
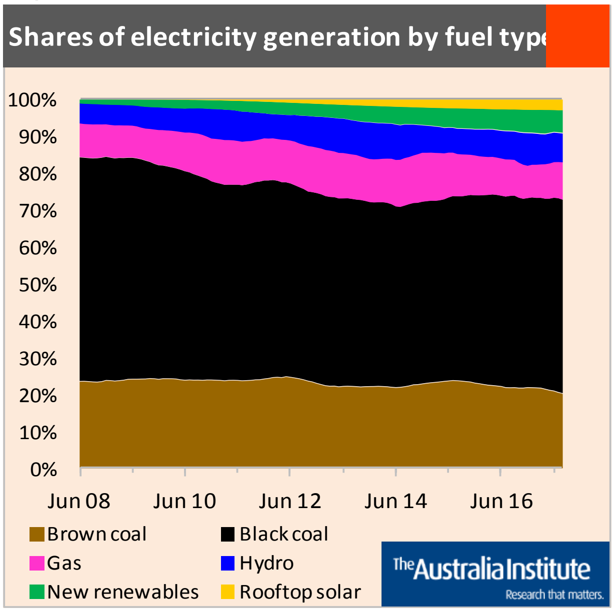


Figure 4



Figures 3 and 4 provide another way of looking at the data represented in Figure 2. The total share of coal in NEM generation decreased until June 2014; since then it has actually increased slightly. When gas is added, in the four years since mid-2013 the total fossil fuel share of generation has actually increased, from 85.3% to 85.5%. The renewable generation share of total NEM generation has correspondingly decreased, 14.6% to 14.5%. These changes reflect the effects of both the short-lived carbon price – increasing, then decreasing, hydro generation – and of the near freeze in new renewable generation investment during the prolonged period of indecision, hostility, and policy cut-backs under the Abbott Government.

Renewable Generation in the NEM

The volume of renewable generation supplying the NEM has grown steadily. Figure 5 below, separates renewable generation into the various “old” (hydro) and “new” (wind, solar, biomass) types. Increases in generation have been driven primarily by wind and rooftop solar, with considerable variation coming from hydro depending on seasonal factors.

Figure 5

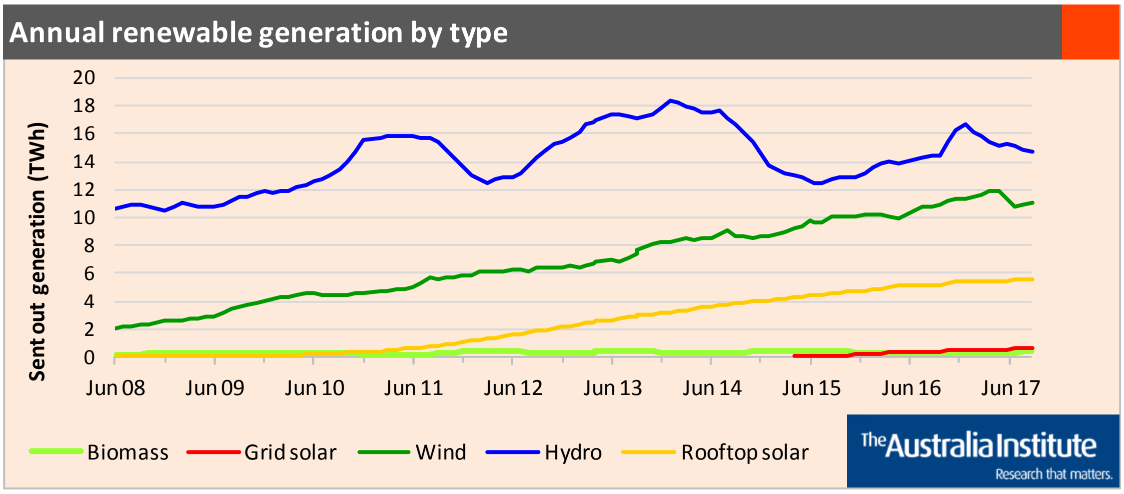
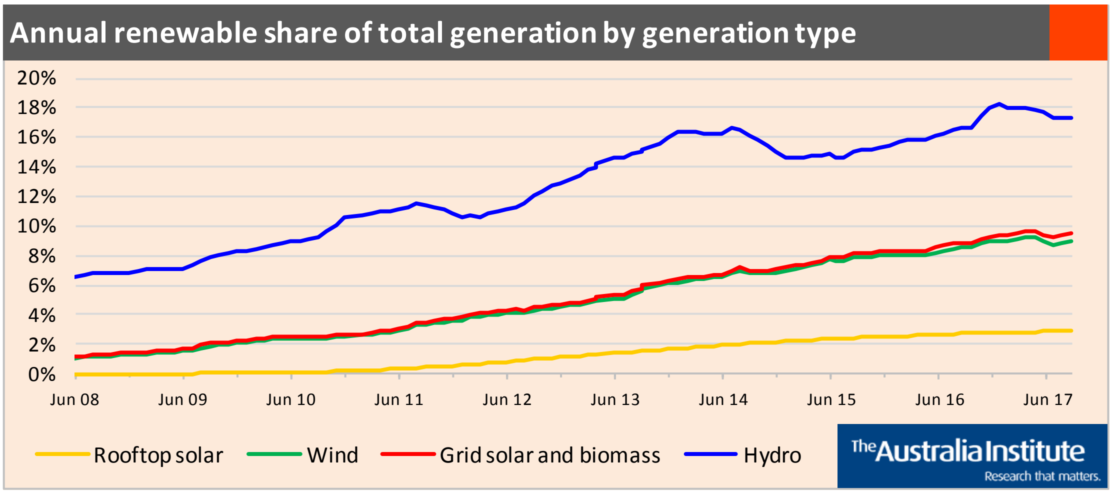


Figure 5 above shows the absolute change in generation of each generation type. By contrast, Figure 6 below shows the share of electricity supplied by the various technologies.[1] Note that the lines in Figure 6 are stacked, showing total renewable generation growing from 6.5% to June 2008 to around 18% more recently:

Figure 6

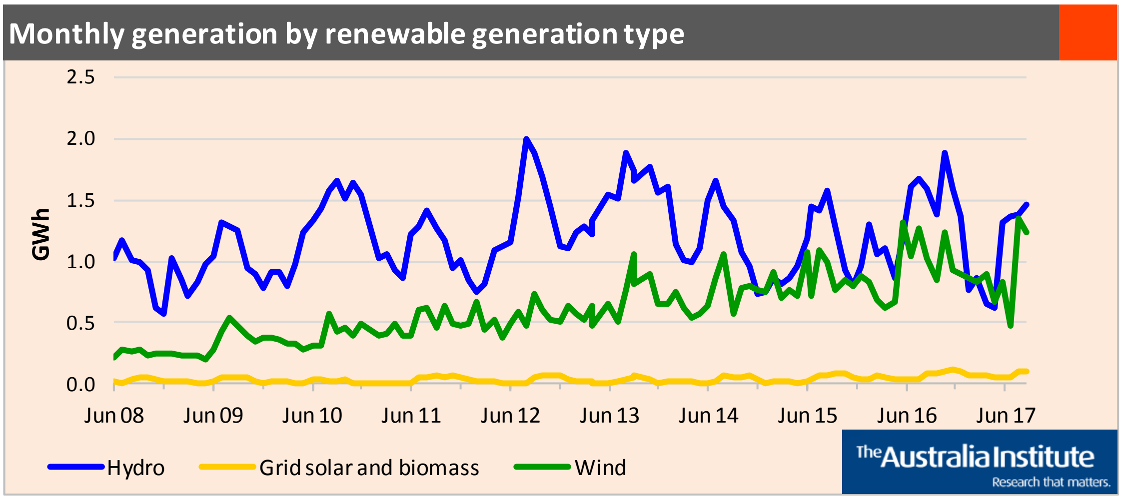


Finally, Figure 7 shows month by month shares of total NEM generation contributed by the different renewable generation types and shows that total wind generation in August was again very high. On Wednesday 16 August, an average of 3,629 MW was supplied to the NEM by wind generators, the highest level recorded to date. During the 11 pm trading interval (10.30 to 11.00 pm) wind provided more than 17% of total grid level NEM generation. It may be some time before this record is exceeded because on 3 September AEMO introduced a

[1] Note that these data do not include generation by small hydro, biomass, and landfill gas generators embedded within the various distribution networks. According to the public data on annual generation and emissions from the National Greenhouse and Energy Reporting (NGER) Scheme, these small renewable generators supplied an amount of electricity which would have added about 1% to the total shown in Figure 6.

restriction on wind generation in SA, capping the total at 1,200 MW, for reasons of system security. (The total nameplate capacity of SA wind generators is just under 1,600 MW.) This restriction was achieved by obliging most wind generators in the state to curtail their output on a proportionate basis.

Figure 7



The following day (17 August), the combined share of wind and hydro generation in total grid level NEM generation reached 25% of grid level sent out generation, just at the time of evening peak. Earlier in the day, total renewable generation, including rooftop solar, reached over 30% of total generation, large and small, across the NEM.

Figures 5, 6 and 7 are new to *NEEA Electricity Update* and will be a regular feature from now on.

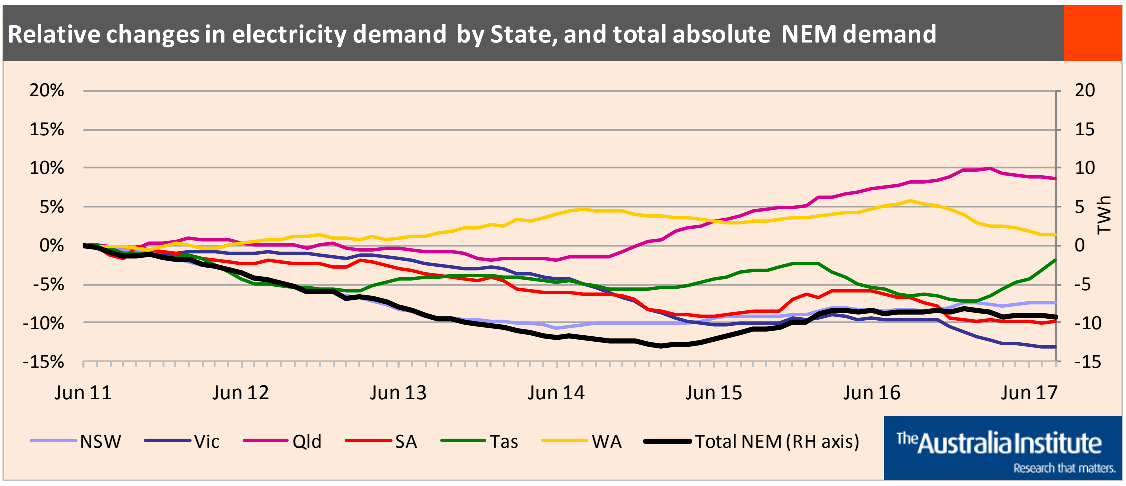
During both July and August, Victoria was a net importer of electricity from SA, reversing the more usual pattern of net exports. In August, Victoria in turn was a net exporter to NSW. These patterns of electricity interconnector flows add further weight to the suggestion, made in the August *Electricity Update,* that a new interconnector between SA and NSW could be beneficial. For SA it would add to system security by providing a new independent interconnection, a new source of supply at times of low wind output, and at times of high wind output would provide more capacity to access interstate demand.

For NSW, an interconnector to SA would provide more access to low cost supply at times of high wind generation in SA. For the NEM as a whole, strengthening interconnection would contribute to reliability by enabling spatial diversity of renewable generation. During the very windy period at the end of August and the beginning of September, wind generators in the mid-north area of SA reached high levels of output about one day before Taralga wind farm, in southern NSW and two days before the newly commissioned White Rock wind farm, in northern NSW. The same lag was seen as output in SA started to drop after more than three days of very high output. In its recent *Statement of Opportunities Report*, AEMO concludes that greater spatial diversity of wind and solar generation (which it calls its dispersed scenarios) contributes to reducing the risk of load shedding.

Demand

Figure 8 shows the relative changes, since the year ending June 2011, in total annual demand for electricity in each of the five regions of the NEM, and also in Western Australia's main electricity grid. There has been virtually no change in the trends reported in the August *NEEA Electricity Update*. Demand is decreasing in Victoria and Queensland, and also in Western Australia, it is increasing in New South Wales, and almost exactly constant in South Australia. The rapid increase in Tasmania is mainly the delayed effect of returning demand from industrial consumers forced to cut electricity consumption and production while the Basslink cable was broken.

Figure 8



As previously explained, demand, as plotted in Figure 8, includes only demand for electricity supplied to network businesses from the transmission grid.

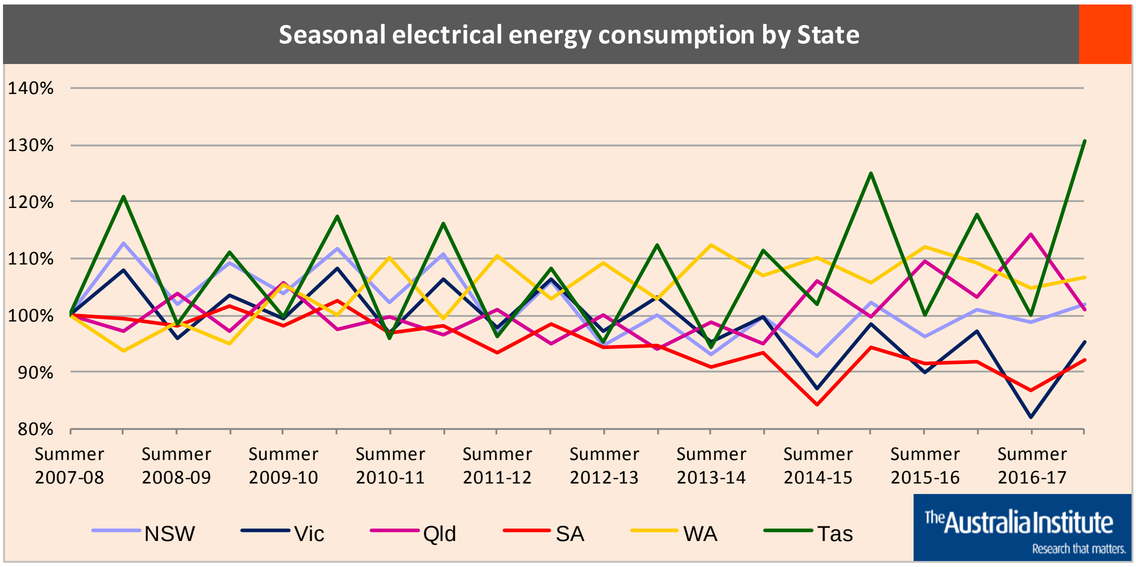
A peek at peak demand

In April and September each year, *Electricity Update* looks back at electricity consumption and peak demand during the season just ended. In every state and every year, consumption is higher in the four winter months of May to August because of heating requirements, in the four summer months December to March because of cooling requirements, while electricity consumption is lower in April, September, October and November. Figure 9 shows trends in seasonal total electricity consumption in each state, relative to summer 2007-08.

It shows, firstly, that more electricity is consumed in the winter months in every year in NSW, Victoria, SA and Tasmania. In Queensland, consumption is consistently higher in the summer months than in winter. This difference is easily explained by the respective average climates of each state. WA is an interesting case, in that the climate of Perth and the South West (the area coved by the main grid) is obviously less warm than Queensland, but it nevertheless uses more electricity in summer. This is probably explained by the widespread use of gas for space and water heating in WA, meaning that the seasonal influences on electricity consumption are weaker.

The second point is that, unsurprisingly, the trends in seasonal electricity consumption are the same as the trends in total annual consumption, shown in Figure 8. Consumption in Victoria and SA has been decreasing for some years. Consumption in NSW decreased sharply a few years back, but is now slowly growing. In Queensland, electrification of the equipment used for coal seam gas extraction drove a strong increase in consumption, but that process is now complete and consumption growth has levelled off. The very large increase in electricity consumption in Tasmania is harder to explain; since it seems to be more pronounced in winter than in summer. A possible cause is a fuel shift away from wood fuelled space heating, which is very common in Tasmania, to electricity. Note that there is very little use of gas for heating in Tasmania. It is also important to recognise that changes in seasonal weather conditions from year to year are another factor affecting changes in seasonal electricity consumption.

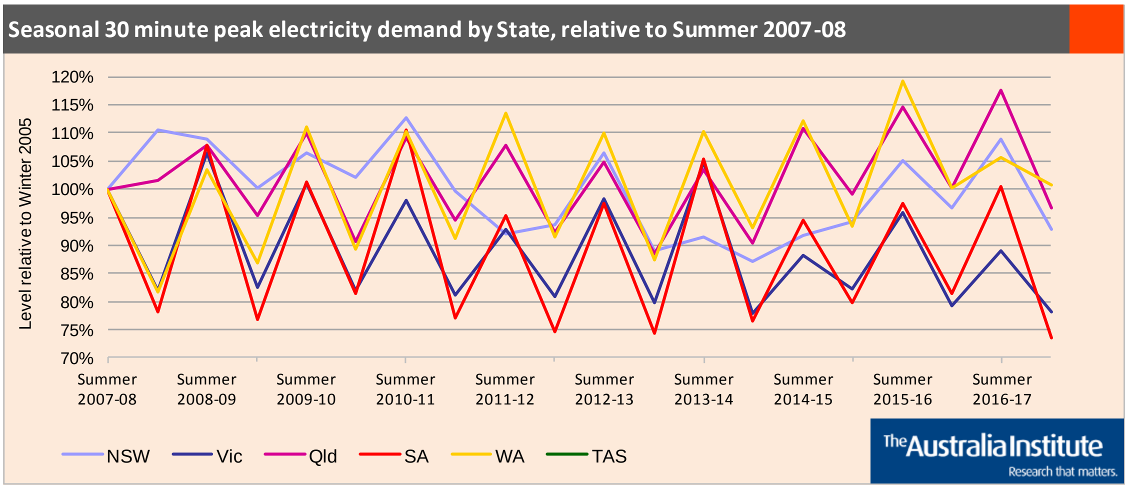
Figure 9



Year to year variations in seasonal weather have a much more pronounced effect on seasonal peaks in demand for electricity, which are shown, again in relative terms, in Figure 10, based on the highest seasonal average demand each year over a 30 minute trading interval. Peak demand over a 5 minute trading interval will be slightly higher and instantaneous peak higher again, but using a 30 minute peak is an adequate approximation for understanding the system requirements to meet peaks.

The first point to note here is that system peak is consistently higher in summer than in winter in every state except Tasmania (which is not shown), reflecting, of course, the heavy demands for space cooling on very hot days. The second point is that three states – NSW, Victoria and SA – experienced their highest system peaks some years ago: in 2009 in Victoria and 2011 in NSW and SA. Only in Queensland did the highest ever peak occur last summer. In WA the highest peak was in 2016. The August issue of *Electricity Update* explained how all electricity consumers are now paying for the over-build of network capacity, supposedly required to meet ever increasing demand peaks, which have not eventuated.

Figure 10



One of the most interesting features of summer peak demand is that the peaks tend to be very sharp and much higher than demand at all other times. An examination of demand in Victoria throughout 2008-09, the year in which the record peak occurred, shows that the top 2% of demand during the year, equal to 210 MW, occurred during just eight hours, of which seven were on 29 January and one on 30 January 2009. Since then, widespread uptake of rooftop PV has had the effect of lowering peaks, making them occur later in the day (commonly now around 5 and 6 pm, rather than in the early afternoon, as used to be the case) and making them shorter.

What does AEMO do to ensure peak demand is met?

One of the annual responsibilities of AEMO is to produce a 20 year forecast of total annual electricity consumption and peak annual demand in each state in the NEM. This is normally published in June of each year, as the *National Electricity Forecasting Report*. It is followed, again each year, by the *Electricity Statement of Opportunities (ESOO)*, which combines the forecast results with what is known about generating capacity available each year, because it is either already operating or under construction. On this basis, the *ESOO* assesses whether available capacity will be sufficient to meet both forecast energy consumption and forecast peak demand. For meeting peak demand, AEMO uses a probabilistic approach to estimate the capacity likely to be available at any particular time. This approach allows for the possibility that wind generation may be at low levels and/or that units at coal and gas power stations may suddenly fail.

The *ESOO* is usually published in September each year. Its purpose is to provide reliable advice to potential investors about what types of new supply capacity will be needed to meet both total annual electrical energy consumption and peak demand, how much, and when. As such, it is one of the most important components of the standard operation of the competitive

National Electricity Market. The *ESOO* has been pointing out for several years that SA would need new capacity by 2019 or 2020. The date has been brought forward by the sudden closure of Hazelwood power station (announced from Paris on 3 November 2016, fully closed 30 March 2017), following which both AEMO and the two state governments started planning to minimise the risk of supply shortfalls next summer.

This year's *ESOO*, published on 4 September, was not a special report, as some commentary has implied, but simply AEMO going about its normal activities. The report describes the measures it expects to be in place to avoid the need for load shedding on peak demand days in Victoria and SA next summer, and concludes that it will be possible to avoid blackouts.

By contrast with the closure of Hazelwood, AGL, the owner of Liddell power station, announced in 2015 that it intended to close it in 2022, giving plenty of time for new investments to ensure there would no supply shortfalls when the time came. On the basis of investments already in train, as described above, AEMO concludes that:

> *The likelihood is between 29% and 46% that USE [Unserved Energy] will eventuate in New South Wales in 2024–25, averaging from 224–290 MW and lasting from two to six hours (depending on supply and demand variations)*. (p. 19)

AEMO clearly states that its calculations of the probability of supply shortfalls after the closure of Liddell, and the higher probability if it is followed by a second, as yet unannounced closure (Vales Point 1,320 MW), assume that the capacity being closed is "not replaced by firm capacity or demand response" (p. 20). The whole purpose of the *ESOO* is to give unambiguous and well founded advice to potential investors about future requirements for new capacity and capabilities, well in advance of these being required, so as to enable the required new investments in firm capacity or demand response to be made.

The reason that the closure of Liddell is likely to present only such a relatively small challenge to supply reliability relates to the nature of peak demand in the electricity supply system of southern Australia. Figure 10 shows that both New South Wales and South Australia experienced their highest peak demands for six years, in New South Wales, and three years, in South Australia. These peaks were associated with the same heat wave, which climaxed in South Australia on 8 February and in New South Wales on 10 February. Blackouts (see below) were imposed on some electricity consumers for a few hours in each state on the respective peak days, in order keep the electricity system as a whole operating securely.

We have analysed the trading interval (30 minute average) demand data for the whole 2016-17 year in each state, adjusting demand on those two days to add an estimate of the quantities blacked out. The analysis shows that in New South Wales, the top 2% of demand in the year, equal to about 290 MW (none of which had been needed for the past six years) occurred during just two hours on 10 February. The top 5% occurred over 5.5 hours, on 10 February and one other day in January, and on a handful of hours during the preceding five years. In South Australia during 2016-17, the top 2% of demand for the whole year occurred during two hours on 8 February and 30 minutes on 9 February. This top 2% equated to about 60 MW (none of which had been required during the preceding three years). The top 5% occurred over 6.5 hours, also on the same two days. The same pattern of the extreme peak demand occurring for only a few hours every few years is also seen in Victoria.

To eliminate any risk of black outs on future peak days (which may not be as high again for several years), an extra few hundred MW of capacity may be needed for a handful of hours, possibly not every year, just as AEMO says in the quotation above.

But the government apparently wants all risk of blackouts to be eliminated in New South Wales, and it wants to do this by keeping Liddell, an ageing 2,000 MW coal-fired power station, in sound operational condition for at least five years past its announced closing date of 2022.

How well did Liddell perform when, for the first time for at least six years, its capacity was really needed, on 10 February?

Liddell and February 2017 peak demand

The extreme hot weather which hit NSW on 10 February climaxed in South Australia on 8 February, which also experienced its highest peak for several years. Like New South Wales, it would have been higher but for load shedding, which affected general consumers across several parts of Adelaide.

We now turn to look in detail at the contribution of the different generation types to meeting the peak demand on 10 February in New South Wales.

Firstly, solar and wind performed as expected. Secondly, gas generators also performed as expected in the lead up to the peak – but at the crucial time output from two of the three largest generators, Colongra and Tallawarra, suddenly dropped to zero for an hour or two.[2]

This placed a particular burden on coal generation, which is of course the major source of supply in the state. Figure 11 shows how coal performed. The graph shows total nameplate capacity for the five coal-fired power stations in New South Wales, the capacity actually made available in bids during each 30 minute trading interval, and the capacity actually generated. The nameplate capacity of NSW coal generation is just over 10,000MW. Figure 11 shows that the coal generation that operators made available on those days was far lower than this – about 8,500 MW at the peak time. The coal generation actually sent out was lower still, only generating between 7,000 and 8,000MW during the peaks of demand above 12,000MW. When blackouts are threatening, coal generators would normally make everything they had available. That did not happen 10 February; at the crucial time, around 5 pm, available capacity was 1,800 MW less than nameplate capacity. Why?

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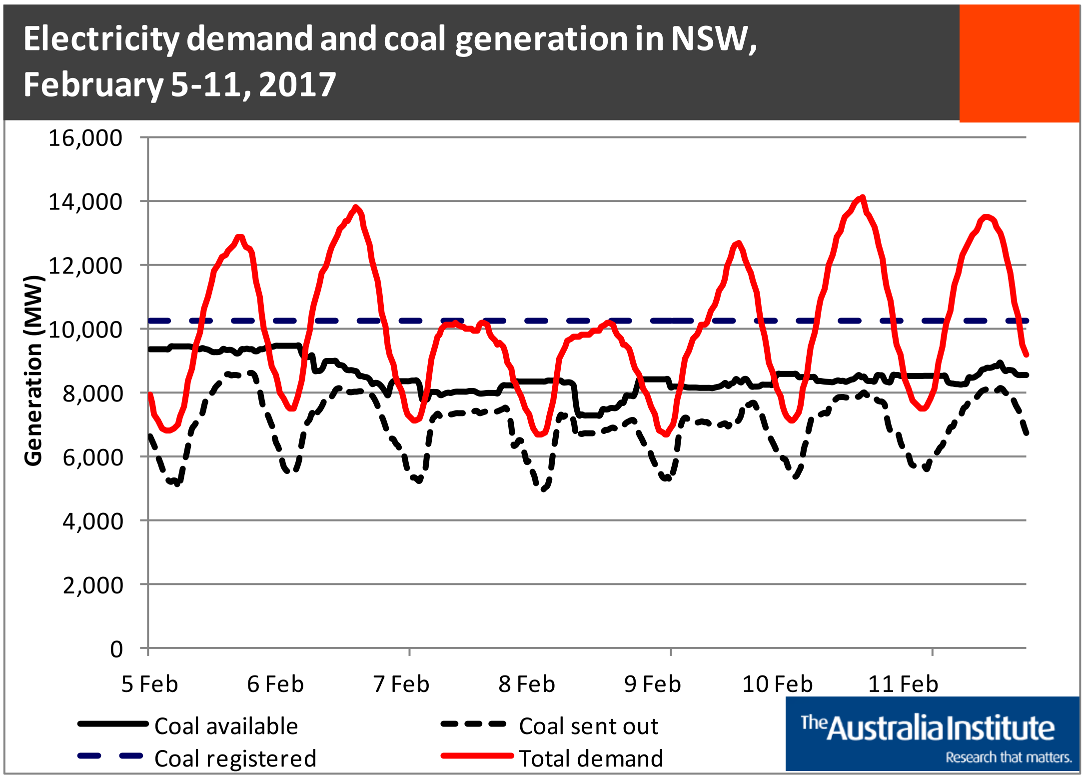
[2] AEMO (2017) *System event report New South Wales, 10 February 2017,* http://www.aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2017/Incident-report-NSW-10-February-2017.pdf

Figure 11



Coal generation was below capacity because Liddell power station broke down with boiler tube leaks.[3] Two of the four 500 MW units were completely out of action: Unit 4 stopped generating on 6 February and Unit 4 stopped on 9 February. Unit 3 also completely broke down on 6 February, but was brought back on 9 February, but neither Unit 1 nor Unit 3 was at full capacity. In addition, all of the four 720 MW units at Eraring power station were operating significantly below nameplate capacity, presumably because high cooling water temperatures (as a result of the hot weather) reduced their operating efficiency.

Finally, hydro generation played a crucial role at the peak period, with the large Lower Tumut (Talbingo) power station operating at 200 MW above its 1,500 nameplate capacity for 3 hours. This was only possible because three of the six machines at Talbingo are also fitted with pumps, making it Australia's largest pumped hydro system, and the station operator, Snowy Hydro, had been doing a lot of pumping over several weeks prior to 10 February.

Nevertheless, it was necessary to cut supply, in turn, for one hour at a time, to each of the three 290 MW potlines at Tomago aluminium smelter. In other word, it was only because contractual arrangements allowed Tomago smelter to be "blacked out" that no other customer had to have electricity cut off.

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[3] AGL (2017) *AGL and Tomago agreement in place to curtail electricity,* https://www.agl.com.au/about-agl/media-centre/asx-and-media-releases/2017/february/agl-and-tomago-agreement-in-place-to-curtail-electricity

If Liddell had been able to operate as it was supposed to, there would have been no need to cut supply to Tomago. Nor would other industrial and commercial electricity consumers across NSW and the ACT have had to voluntarily reduce their consumption, without financial compensation, in response to urgent appeals from the state and territory government ministers.

These failures demonstrate that fossil fuel generators are not a silver bullet to reliability of energy supply. Right when NSW consumers needed them most, important gas and coal generation went missing in action.

Conclusion

The government apparently believes that it is essential to eliminate all risk of blackouts for a few hours on one or two days per year, or fewer, after 2022. It is hard to think of a more expensive and unreliable way to achieve this objective than prolonging the life a 50 year old coal-fired power station with a long history of unreliable performance.

The failures of key fossil fuel generators during peak periods of demand demonstrate that coal and gas generators are not a silver bullet to reliability of energy supply. Right when NSW consumers needed them most, important gas and coal generation went missing in action.

AEMO, ARENA and other agencies now have a strong focus on implementing firm demand response capabilities across the NEM. Despite the many incentives which still favour supply augmentation over demand response, it is hard to believe that they will not succeed over the next four years. It is even harder to believe that this will not be a far cheaper, not to say less environmentally damaging way, of meeting the relatively tiny amounts of capacity needed to ensure all consumers who need electricity on peak demand days are supplied with all that they require.

Appendix: Notes on methodology

All data are reported as annual moving averages. This approach removes the impact of seasonal changes on the reported data. Annualised data reported in *NEEA Electricity Update* will show a month on month increase if the most recent monthly quantity is greater than the quantity in the corresponding month one year previously. Most data are presented in the form of time series graphs, starting in June 2011, i.e. with the year ending June 2011. Some graphs start in June 2008. These starting dates have been chosen to highlight important trends, while enhancing presentational clarity.

Defining the particular meaning of the various terms used to describe the operation of the electricity supply system will help in understanding the data discussed in this and all other issues of *NEEA Electricity Update*.

Demand, as defined for the purpose of system operation, includes all the electricity required to be supplied through the grid level dispatch process, operated by AEMO. This includes all the electricity delivered through the transmission grid to distribution network businesses, for subsequent delivery to consumers. It also includes energy losses in the transmission system and auxiliary loads, which are the quantities of electricity consumed by the power stations themselves, mostly in electric motors which power such equipment as pumps, fans, compressors and fuel conveyors. Auxiliary loads are very large: in 2011 they amounted to 6.3% of total electricity generated and currently amount to about 5.6%. Most of this load is at coal-fired power stations, where it can be as high as 10% of electricity generated at an old brown coal power station and 7% at a black coal-fired power station. Auxiliary loads are much lower at gas-fired power stations, and close to zero at hydro, wind and solar power stations. Both demand and generation, as shown in the *Electricity Update* graphs, are adjusted by subtracting estimates of auxiliary loads. Thus demand, as shown, is equal to electricity supplied to distribution networks (and a handful of very large users that are connected directly to the transmission grid) plus transmission losses.

Generation is similarly defined to include only electricity supplied by large generators connected to the transmission grid. It does not include electricity generated by rooftop PV installed by electricity consumers, irrespective of whether that electricity is used on-site ("behind the meter") by the consumer, or exported into the local distribution network. From the perspective of the supply system as a whole, the effect of this generation, usually termed either "embedded" or "distributed" generation, is to reduce the demand for grid supplied electricity below the level it would reach without such distributed generation. That effect can be clearly seen in the regular total generation graph; the gap between the red line – electricity sent out to the grid from large grid connected power stations – and the yellow line – that electricity plus estimated electricity generated by distributed solar systems – is the electricity supplied by those systems, which for the year ending June 2017 was about 5.5 TWh, equivalent to nearly 3% of the combined total.