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NATIONAL ENERGY EMISSIONS AUDIT

National Energy Emissions Audit - Electricity Update

Combined issue, October/November 2017

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

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Introduction

Welcome to a combined October/ November 2017 issue of the *NEEA Electricity Update*, the companion publication to the *National Energy Emissions Audit Report*. The *Electricity Update* presents data on electricity demand, electricity supply, and electricity generation emissions in the National Electricity Market (NEM). This month, the *Update* covers two months, from beginning of September to the end of October.

Each issue of *Electricity Update* contains a more detailed discussion of one or two topical issues relating to the electricity system. This extended edition looks at a number of aspects of electricity supply in South Australia. These include record levels of wind generation, the effect of growing rooftop solar generation on demand for grid electricity, and the effect of both these on spot wholesale prices, which in both September and October were the lowest amongst all four mainland NEM states. We also discuss what implications the smooth, low-cost operation of the state's electricity system throughout this period may have for the proposed National Energy Guarantee in the three larger NEM states, all of which currently have a much lower share of variable renewable generation than South Australia.

Key points

NEM electricity generation emissions fall for the third and fourth successive months

Total annual emissions from electricity generation in the NEM in the year to October fell for the fourth successive month, close to the minimum achieved under the carbon price.

Total NEM demand almost unchanged and WA demand slightly down

Total demand for electricity In the NEM in the year to September 2017 was almost unchanged for the fifth successive month, while a slight decrease was seen in Western Australia.

Brown coal generation continues to fall, with gas and wind contributing to the replacement

Very high wind generation across the NEM in both August and September saw the continuing fall in annual brown coal generation, following the closure of Hazelwood Power Station. This supply was replaced entirely by a mixture of gas and wind generation in September.

Wind generation in September sets a new record across the NEM

During September, wind generators supplied 9.7% of all electricity supplied to the NEM grid, far above the previous record of 8.6% set in May 2016, with record levels in Victoria, New South Wales and Tasmania. Performance was particularly strong in New South Wales where three windfarms achieved monthly capacity factors of over 60%.

South Australia achieves high wind share and low wholesale prices

Wind accounted for 52% of large-scale generation in September and 45% in October. During this period, the average wholesale price was markedly lower than in the other three mainland NEM states.

States with higher renewable energy share experienced lower wholesale prices

In September and October, states with higher levels of renewable generation had lower wholesale prices, with Tasmania having the lowest prices and Queensland the highest.

Changing patterns of demand makes demand response increasingly attractive

South Australian has seen substantial changes in demand patterns over the last decade, with *lower average demand and increased 'peakiness'.* These trends are being driven by rooftop solar reducing grid demand, and make demand response increasingly attractive.

South Australia shows a high renewable generation is compatible with reliable supply

The operation of the system in South Australia shows flexible operation of gas generators is able to combine with high shares of wind generation to provide reliable electricity supply. This raises doubts around proposed limits to renewables under the proposed *National Energy Guarantee* and whether coal generators can also be operated with the same flexibility.

Generation and emissions

Total annual emissions from electricity generation in the NEM fell to the end of October for the third and fourth months in succession. Between the years to August and October 2017, electricity emissions fell by 1.2 Mt CO_2-e, equal to a drop of 0.7% (see Figure 1), while total generation decreased by 0.1%. The main driver of lower emissions has been the closure of the highly emissions intensive Hazelwood Power Station during the last week in March, reflected in the ongoing decline in the year-to-date emissions. Since April, gas generation in Victoria and South Australia, with emissions intensity around 40% or less than that of Hazelwood, has steadily increased, to make up for the loss of supply. Until July, replacement supply also came from black coal generators in Queensland and New South Wales, with emissions intensity less than two thirds that of Hazelwood. From July to August, persistent windy weather provided a surge in zero emission wind generation, offsetting the big fall caused by almost windless conditions in June, displacing black coal generation and accelerating the fall in total NEM emissions (Figure 2). However, in October wind generation fell back somewhat and hydro generation was also reduced, resulting in a small increase in black coal generation.

Figure 1

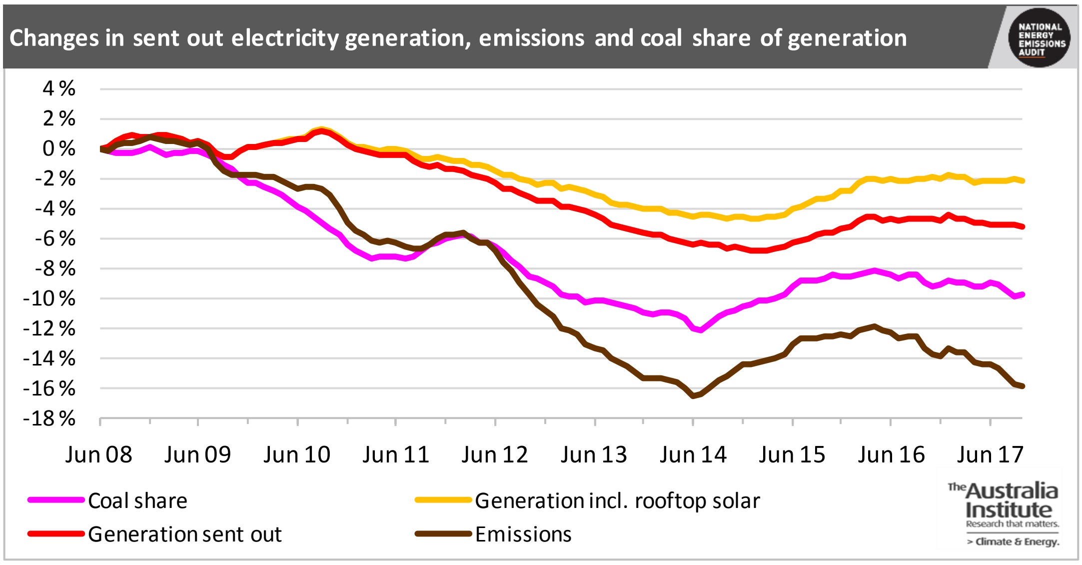
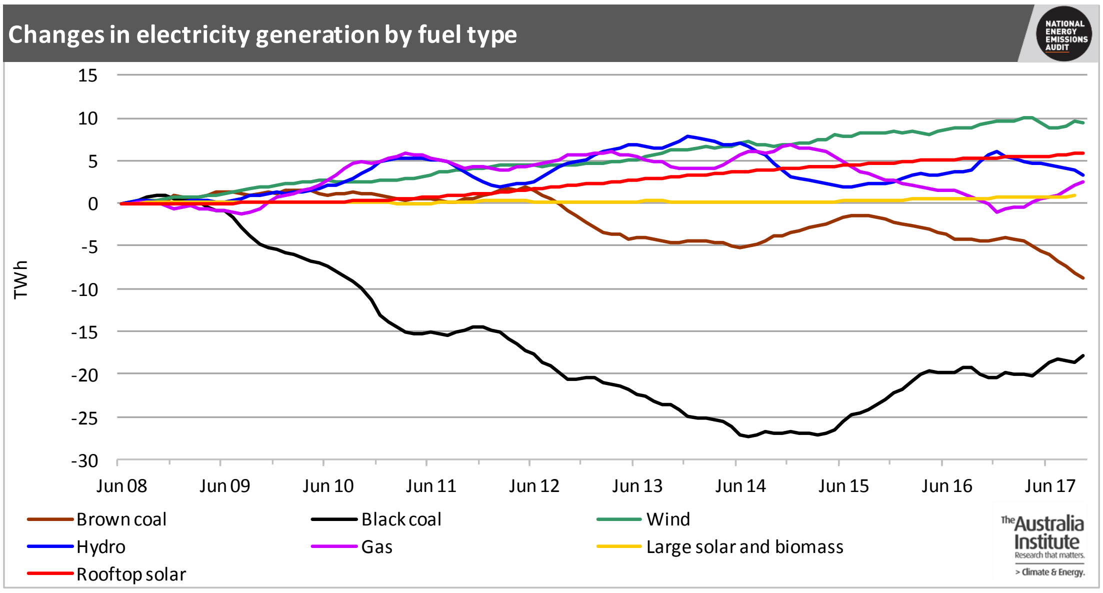


Figure 2



Figures 3 and 4 provide another way of looking at the data represented in Figure 2. Total coal share of NEM generation decreased until June 2014. From then until early 2016 it increased, driven almost entirely by demand for electricity, supplied by coal, to power equipment in the Queensland coal seam gas fields. With this process now complete, and Hazelwood closed in Victoria, the total coal share of NEM generation is now generally falling slowly, though with some month to month variation. In the year to October 2017, the coal share was 74.4% (sent out). However, this remains higher than the 72.6% share that coal reached in July 2014, at the end of the carbon price period. Figures 2, 3 and 4 all show that reduced brown coal generation, following the closure of Hazelwood, is the main reason for the lower total coal generation.

So far as Victoria alone is concerned, comparing the seven months since March this year with the corresponding period in 2016 shows that removal of Hazelwood has been made up mostly by increased in-state generation and decreased exports to both New South Wales and South Australia. There was also a modest decrease in total electricity consumption.

Figure 3

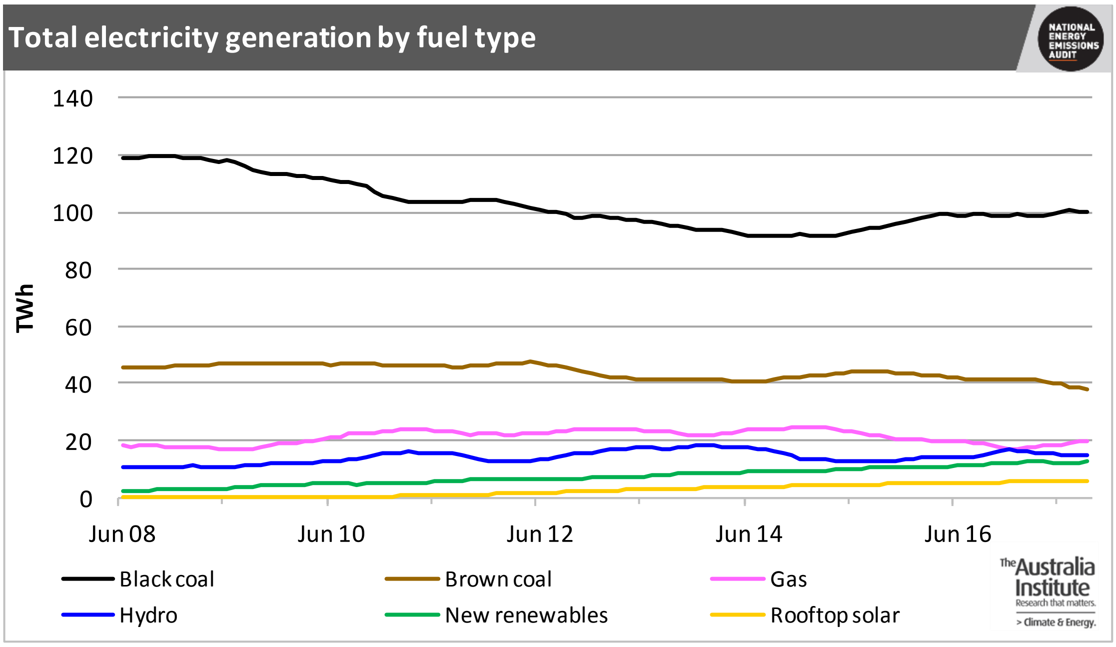
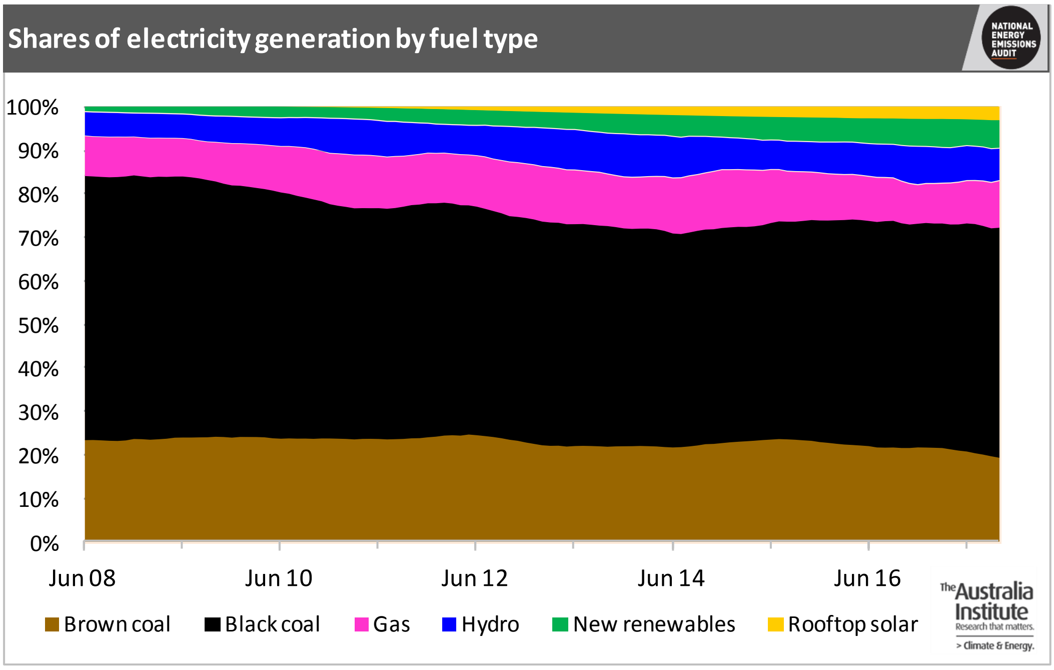


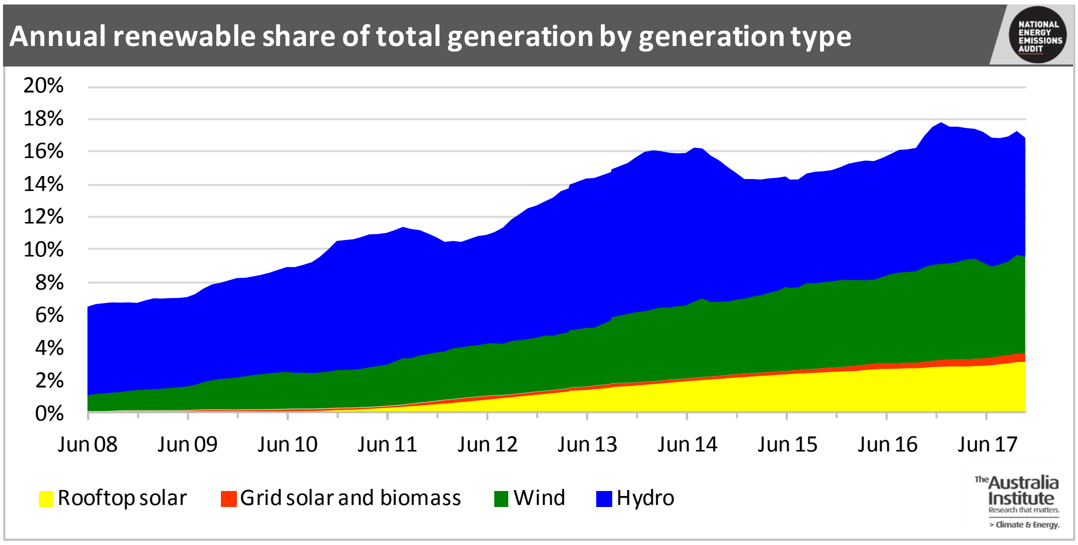
Figure 4



More detail on renewable generation in the NEM is provided in Figures 5, 6 and 7.

Figure 5 shows the growing share of renewable generation supplying the NEM, separated into the various "old" (hydro) and "new" (wind, solar, biomass) types of generation, presented in stacked format. The steady growth of rooftop solar is also shown and all percentages are expressed in terms of total generation, including both NEM participant generators and rooftop solar. Figure 6 shows the absolute annual quantities of electricity supplied by the various technologies. It can be seen that there was a sharp dip in hydro generation in October, mainly caused by much lower Snowy output during September and October, compared with the same period last year. The difference in performance is most likely explained by the fact that active storage levels is the Snowy system are currently at about 38%, compared with 53% at this time last year.

Figure 5



Total electricity sent out by renewable generators reached 26.4 TWh, equivalent to 14.3% of total generation in the year to October[1], which fell just short of the record levels of last summer, when large calls were made on hydro generation to meet peak demand for electricity on hot days. A significant proportion of renewable generation comes from South Australia and Tasmania. If South Australia and Tasmania are excluded, the renewable generation share in the three big states of the NEM combined is only 7.5%.

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[1] As explained in the September *NEEA Electricity Update*, these figures exclude generation by small hydro, biomass, and landfill gas generators, embedded within the various distribution networks, estimated to contribute an additional 1.8 TWh (1 %) in 2015-16.

Figure 6

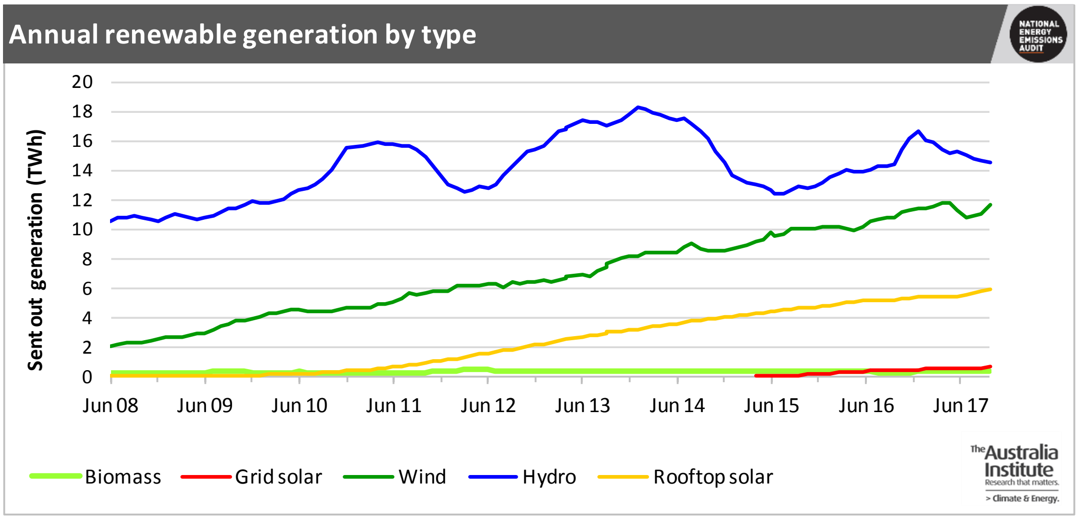


Figure 7

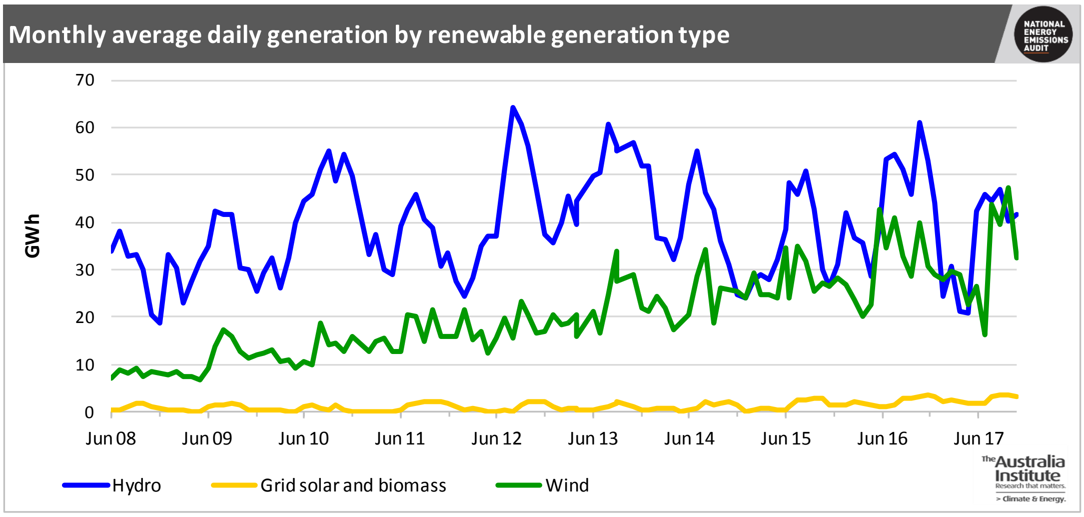


Figure 7 shows month by month daily average output from the various types of renewable generation. September, which was very windy across south east Australia, was a record month for wind generation in the NEM. Output was also at record levels in New South Wales, Victoria and Tasmania. Wind would probably have also set a new record in South Australia, but for the fact, described in the September *NEEA Electricity Update*, that AEMO curtailed wind generation on a number of occasions under a new procedure intended to enhance system security.

During September, wind generators supplied 9.7% of all electricity supplied to the NEM grid, well above the previous record of 8.6% set in May 2016. The performance of wind generators was particularly striking in New South Wales, where three windfarms – Cullerin Range, Woodlawn and Boco Rock – achieved monthly capacity factors of more than 60%.

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 the WA SWIS (South West Interconnected System), which is the main electricity grid in the state. It also shows the absolute change in total demand in the NEM as a whole. Figure 9 shows the individual state data in absolute terms.

Figure 8

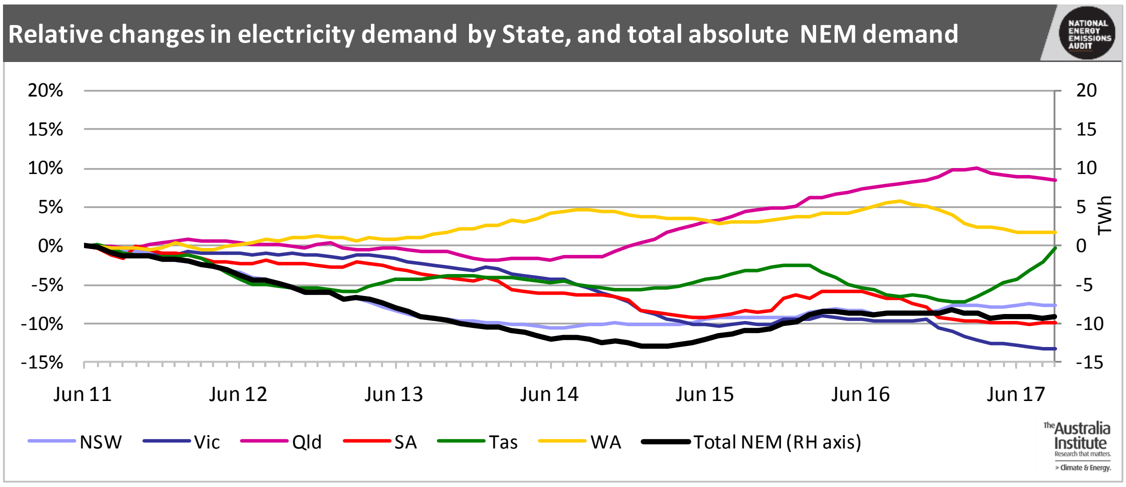
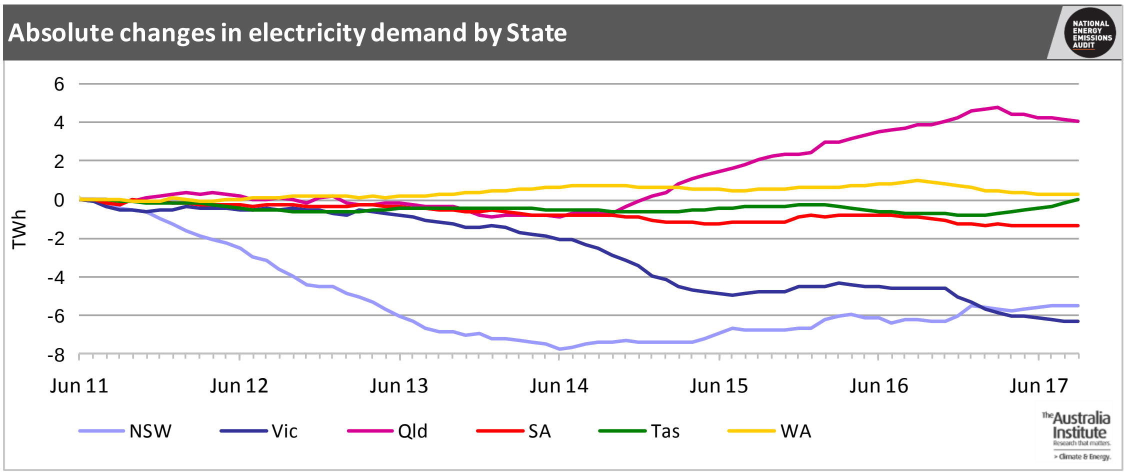


Figure 9



Both graphs show a continuation of trends reported in *NEEA Electricity Update* over the past six months. In Queensland and Victoria, demand is decreasing at rates equivalent to over 2% per annum, while in Western Australia and South Australia it is almost constant. In New South Wales demand is increasing at a rate equivalent to just over 1% per annum, and in Tasmania demand continues to grow at a fast rate. The continuing very strong demand growth in Tasmania, beyond the maximum level reached before the Bass Strait cable break, is a puzzle. Data on demand disaggregated by customer type (residential, commercial, industrial) might help to clarify what is happening, but any such data is unlikely to be available before December.

A more detailed look at South Australia in September and October

Electricity generation

The South Australia region of the NEM has become a focal point for those taking an interest in electricity industry transition, as it has a much higher share of variable renewable generation than any other state region of the NEM, and also more than the South West Interconnected System of Western Australia. Contrary to the ideas promulgated by some opponents of wind generation, most of the substantial investment in windfarms in South Australia is not being paid for by taxpayers or electricity consumers in South Australia, but was and is being built under the nationwide Large Renewable Energy Target (LRET). Under this federal policy, the cost of renewable energy certificates is recovered through retail sales of electricity. Late last year the Australian Energy Market Commission estimated that during 2016-17 the LRET added 0.8 cents/kWh to electricity tariffs, which is less than 4% of the tariff. This is offset by the LRET putting downwards pressure on wholesale prices, as found by numerous analysts. Even discounting this effect, 4% is a reasonable price to pay for what is currently the most important national policy for energy industry development and reducing Australia's greenhouse gas emissions.

The largest windfarm in South Australia, Hornsdale (also the location of the Tesla big battery), is being built under the ACT's feed-in-tariff scheme, not under the LRET. The owners of Hornsdale were able to contract with the ACT Government at a price below $80 per MWh because of the financial security provided by a 20 year contract with the ACT Government. Between January and August this year the owners of Hornsdale were actually paying the people of the ACT, because the level of wholesale prices in the NEM was often higher than the contract for difference price agreed with the ACT Government.

There are two main reasons why South Australians have had a windfarm boom in their state First, there is a lot of wind close to the NEM transmission grid, which means that construction costs are low, and revenue is high. Second, South Australia's government has been welcoming and supportive of the wind industry. Over the same period, governments in Victoria and Queensland, particularly, were hostile and obstructive to windfarm investors. That has now changed in both states.

Wind accounted for 52% of large-scale generation in South Australia in September and 45% in October. If rooftop solar is included, the total renewable share of generation was 55% and 49%, respectively. This can be seen in Figure 10, which plots average daily output by wind and gas generators, as well as output from rooftop solar. Figure 11 shows the same numbers but in stacked format, which makes it easier to see that trade in electricity through the two interconnectors with Victoria shifted from net imports up to June this year to net exports in every month since July. This means that wind generation was larger when expressed as a proportion of electricity supplied from the grid to consumers in South Australia – 57% in September and 50% in October. Figures 10 and 11 also show that the gas share of South

Australian generation during September was just a few percentage points less than the wind share. If generation by rooftop solar is also included, total renewables, i.e. wind plus solar, accounted for a record 55% of all electricity generated in the state during September. After adjusting for net exports of electricity to Victoria during the month, renewable generation was equal to 63% of electricity consumption.

Figure 10

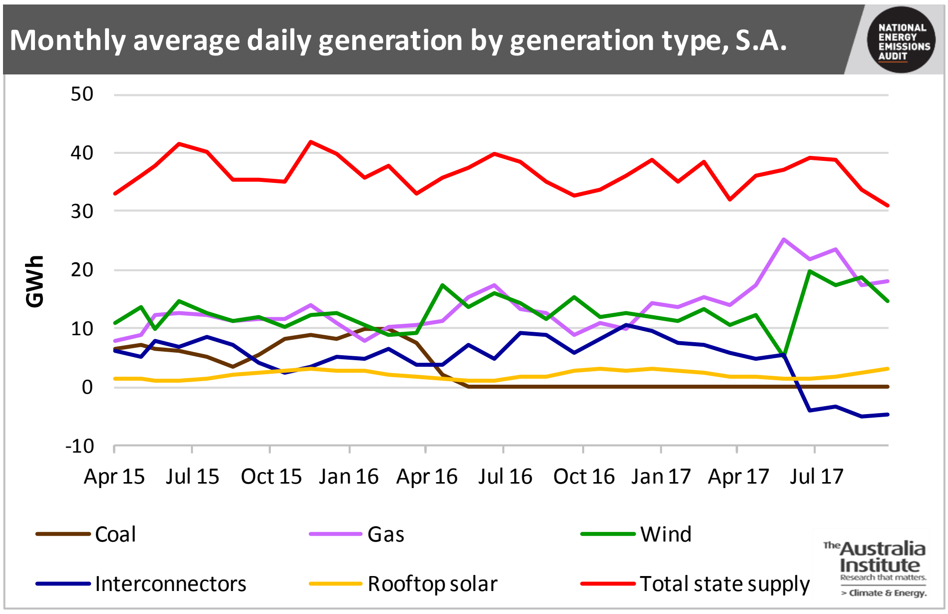
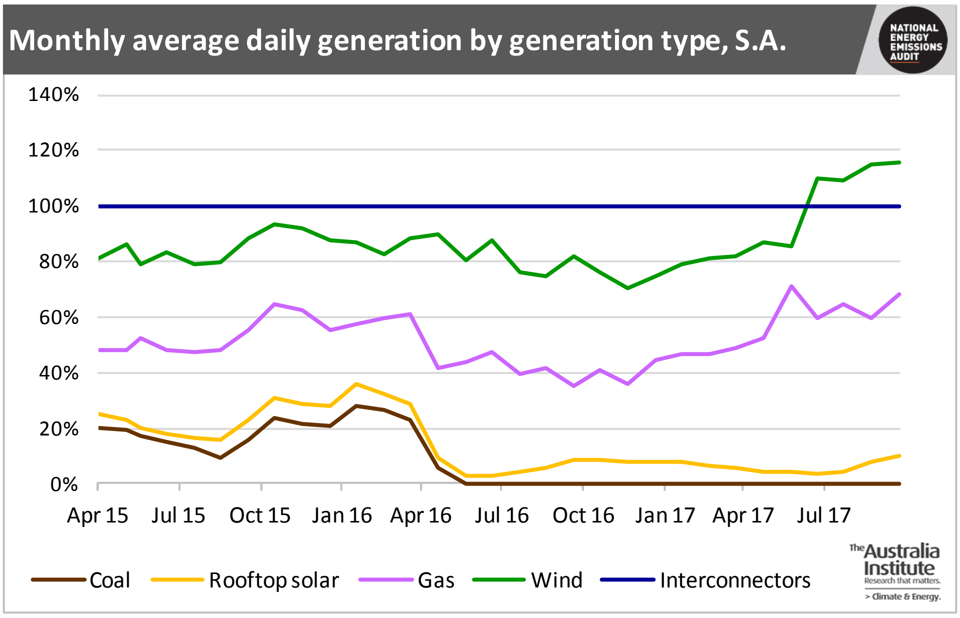


Figure 11



For rooftop solar, although South Australia does not lead other states in installed capacity as it does for wind, it is the leading state in terms of capacity relative to average demand for electricity. Rooftop solar therefore makes a larger contribution to total electricity consumption than it does in other states. Over time, this is having an effect on the operation of the electricity supply system in the state, mainly through its effect on patterns of demand, that is no less profound than the effect of wind generation.

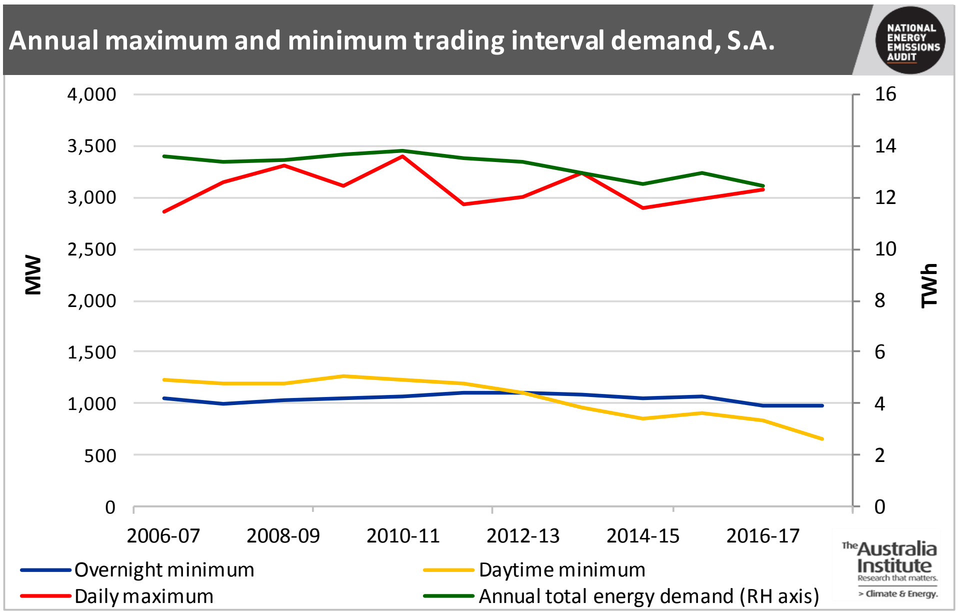
Electricity demand

Demand for electricity from the grid in a country like Australia, where connection to grid electricity is effectively universal, typically shows a marked diurnal pattern. There is a daily low point between around 3 and 5 am, rising rapidly to a peak in the morning, usually dropping slightly during the middle of the day before rising to a daily peak in the early evening, and finally falling steadily to the daily minimum in the early hours of the following morning. Depending on characteristics of the particular grid, and the consumers connected, the minimum annual overnight demand is typically 40-50% of the maximum annual demand.

In addition, demand experiences regular cycles over the year, and peak events, such as during heatwaves. Under the conventional approach to electricity supply, the capacity of all parts of the system, including generation, transmission and distribution, must be rated to meet the peak. This means that a large amount of capital equipment stands unused for most of the year. Up till now, electricity consumers have apparently been willing to pay the cost of this underutilised capital equipment as the price of having an extremely reliable supply of electricity. Industry participants have been more than willing to comply since the National Electricity Rules ensure, through a variety of means, that they will be rewarded, rather than penalised, for such apparent economic inefficiency. Consequently, the alternative approach of reducing demand during those few hours, by means of so-called demand response, has been largely ignored, and often disparaged as unbefitting a developed country. Finally, however, there are real prospects of increased uptake of demand response, particularly driven by the Australian Energy Market Operator (AEMO), under its new CEO.

South Australia is experiencing profound changes in its patterns of demand. These are summarised in Figure 12.

Figure 12



Total consumption decreased from 2010-11 onward, as did annual peak demand. Annual minimum overnight demand has stayed roughly constant, but annual minimum demand in the middle of the day has fallen steadily, and since 2012-13 has been lower than the overnight minimum.

This significant change is largely attributable to rooftop solar generation. In 2007-08, nearly all of the top 2% of 30 minute demand periods occurred before 5 pm local time, many of them well before, when the sun was relatively high in the sky. In 2016-17, most of the top 5% occurred after 5.30 pm local time, some well after, when the sun was much lower. Rooftop solar generation has had the effect of both lowering peak demand on the grid and pushing it to later in the day. No wonder that South Australia is more advanced with trials of demand response than other states.

Changes in demand are also shown by plotting demand in each hour of the year in decreasing order, called an annual load duration curve. Figure 12 shows load duration curves for electricity supplied from the grid, i.e. excluding rooftop solar and other embedded generation, in South Australia in 2007-08 and in the year from November 2016 to October 2017 (henceforward termed 2016-17). It also shows the curve for 2016-17 if generation by rooftop solar is added to generation supplied through the grid. Figure 13 focuses on the top 10% of demand intervals.

Figure 12

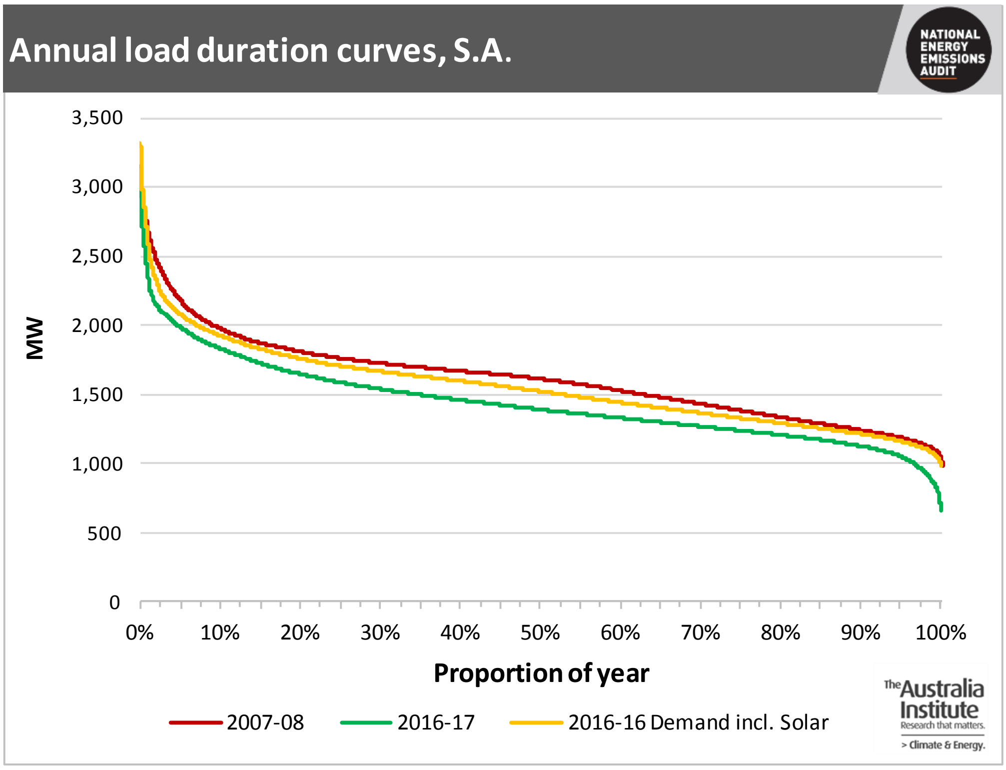
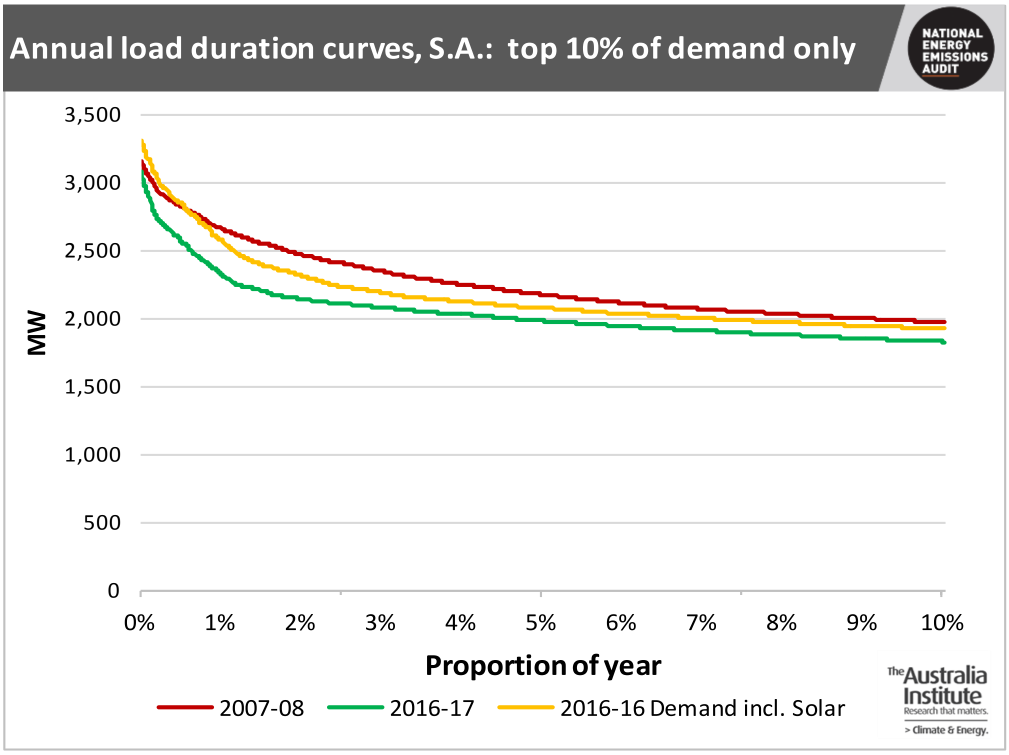


Figure 13



A number of interesting points arise from these figures.

First, rooftop solar generation, which was virtually zero in 2007-08, has been responsible for a large part of the apparent fall in consumption between 2007-08 and 2016-17. The remaining part of the fall reflects (the gap between the red and yellow lines) reflects an actual reduction in total consumption of electricity. In 2007-08 total consumption of grid electricity was 14.-0 TWh, while in 2016-17 it was 12.5 TWh, but 13.5 TWh when rooftop solar is added..

Second, while average demand has fallen, the annual 30 minute peak grid demand was almost the same in the two years. In 2007-08 the median 30 minute demand was 1,615 MW, equal to 52% of annual peak demand. In 2016-7 the corresponding figure was 1,391 MW, equal to 45% of peak demand. Third, rooftop solar has already substantially reduced grid demand. 2016-17 peak demand including rooftop solar was 7% higher than the 2007-08 peak. In other words, rooftop solar has made a very significant contribution to reducing annual peak demand for electricity. However, because the peak has now been shifted to just before sunset, it is unlikely that further increases in rooftop solar capacity will further reducing peak demand.

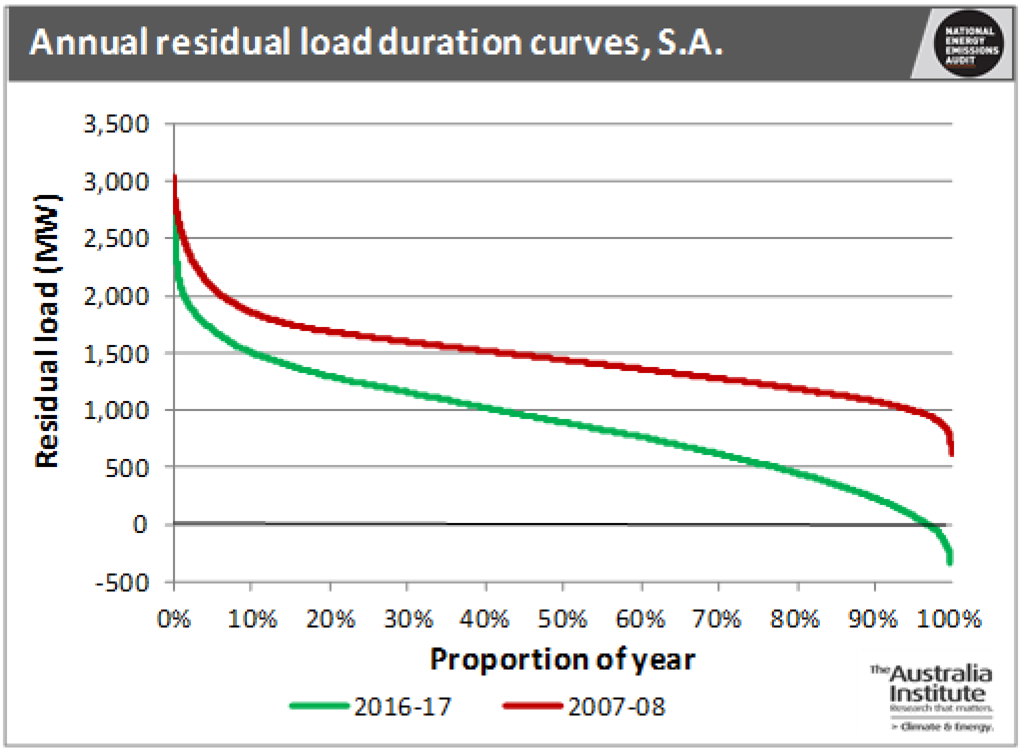
Third, demand was much more "peaky" in 2016-17 than in 2007-08. In other words, grid generation capacity needed to meet peak demand was needed less often, meaning it was less efficient to maintain it year round to meet those peaks. In 2007-08 the top 2% of annual demand occurred during 6 hours over the year, the top 5% over 15 hours and the top 10% during 43 hours. The corresponding figures for 2016-17 were 2 hours, 8 hours, and 16 hours.

Fourth, the minimum annual 30 minute demand (ignoring demand during blackout events) was also lower in 2016-17 than in 2007-08. This was 661 MW (on 2 October) compared with 996 MW (on 20 April 2008). Furthermore, the minimum occurred during the middle of the day, rather than in the early hours of the morning.

These changes make both demand response and batteries potentially very economically attractive in South Australia. With peak demand events occurring for fewer hours, it becomes increasingly feasible and efficient to meet those peaks through incentives to balance supply and demand by reducing demand for short periods, rather than maintaining supply capacity year round sufficient to meet those peaks. Alternatively, batteries would only need to be able to deliver output for brief periods to achieve the same outcome.

While rooftop solar has driven changing patterns of demand, wind generation has produced even more substantial changes in 'residual' demand – grid demand not met by wind generation. Figure 14 shows how the residual load duration curve for South Australia changed over a nine year period from 2007-08 to 2016-17.

Figure 14



The substantial gap between the curves represents the large increase in wind generation in South Australia over this period. Residual demand has also become substantially more 'peaky', with similar a similar annual maximum, but the much steeper slope, meaning that the top 10 to 15% of demand occurs for only a few hours in the year.. Median demand left unmet by wind felling by more than a third and is around a third of the peak. There were much smaller periods in which non-wind grid generating capacity is required to meet the peak and all capacity was much less likely to be operating at any period. The bottom 20% of intervals all had lower residual demand than the minimum demand a year earlier.

In short, increased generation from variable sources not only reduces residual demand but shifts the profile, requiring complementing generation that must operate for fewer hours each year. The graph shows how increased variable wind generation makes battery storage and demand response even more economically attractive – and makes inflexible generation like coal power much less viable.

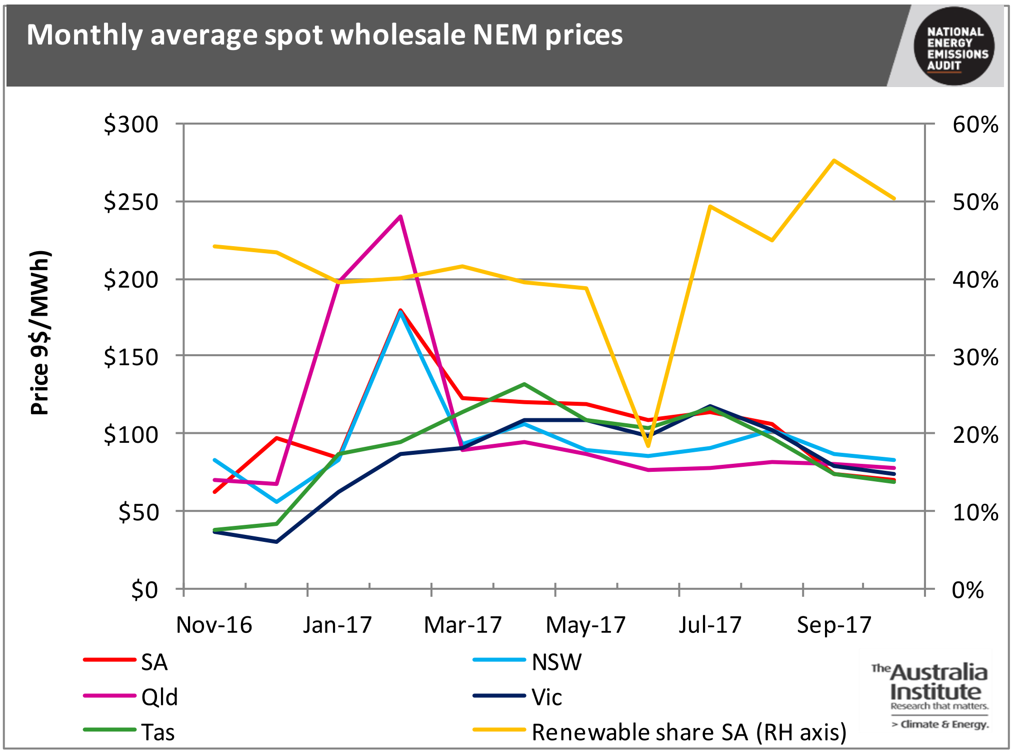
High renewables, low prices, stable supply: implications for re-designing the National Electricity Market

While the increase in wind power in South Australia has been blamed for blackouts and high prices, the recent experience in South Australia does not support these conclusions. High levels of variable wind power, often resulting in exports to Victoria, have been complemented by gas generation, resulting in low prices and stable supply.

The recent experience of South Australia has a number of implications for the design of any mechanism to support reliability and emissions reductions, such as the proposed National Energy Guarantee (NEG) scheme. While the NEG is currently lacking detail, it was released with modelling in which renewable generation at 28-36% in 2030 – with little or no new renewables from the end of the LRET in 2020 – and is touted as supporting 'dispatchable' coal fired power plants. The experience of South Australia in recent months gives grounds for scepticism about such a proposal.

First, average wholesale prices in South Australia throughout the period were lower than in all three other mainland states and only very marginally higher than in Tasmania. As can be seen in Figure 14, the two states with the highest prices during the month were Queensland and New South Wales, the two states with the highest shares of coal generation. Limiting new wind capacity and keeping old coal-fired power stations open is not necessary to reduce wholesale prices.

Figure 13



Second, although the share of variable large scale renewable generation was above 50% during September, and just below during October, there were no problems with the reliability of electricity supply. Moreover, this share was lower than it would have been had AEMO not intervened in the market to curtail wind generation at less than 1,200 MW for a number of hours on various occasions during the month, totalling the equivalent of more than two days. AEMO's interventions were taken to guarantee system security. It is therefore reasonable to assume that AEMO considered the electricity supply system in South Australia to be reliable at all times during September and October, despite the high share of variable renewable generation. During one 30 minute trading interval the wind share of generation was over 80%

and it was over 75% during more than one hundred trading intervals in September, summing to the equivalent in total to over four days in the month.

If this is possible in South Australia why should other states be different? If they are not different, then why does the government propose to constrain renewable generation to 36% or less by 2030? If there is no technical need for such a constraint to guarantee reliability, it is hard to avoid the conclusion that the limitation is driven by ideology.

Third, most of the gas generation during September was supplied by the state's two combined cycle power stations (and for that reason the two most efficient) – Pelican Point and Osborne. The average capacity factor for the month was 78% at Pelican Point and 76% at Osborne. Most of the remaining gas generation came from the ageing Torrens Island A and Torrens Island B stations. Adjusting for the fact that two units at Torrens Island B and one at Torrens Island A were shut, presumably for maintenance which is commonly undertaken in spring and autumn, these two plants had capacity factors of 13% and 43% respectively. The two units in operation at Torrens Island B spent much of the month generating at either 90-95% or at 25-30% of rated capacity. Torrens Island A was totally shut down for six separate extended periods totalling more than half the hours in the month, but was also required to generate at near maximum output over about 6 hours at various times. Such highly variable modes of operation are necessary for dispatchable generators being tasked to balance supply from variable renewable generators. Rapid variation in output and operation at low part-loads are technically feasible for gas generators, though newer gas turbine plants are better suited than the ageing gas-fired steam turbines at Torrens Island. Low capacity operation is also financially feasible, though perhaps not attractive, for old plants like Torrens Island, which are presumably fully depreciated and do not have to carry financing costs.

Elsewhere in the NEM, the rhetoric about the NEG appears to envisage that the variable functionality provided by Torrens Island in South Australia will be provided by coal-fired power stations. They are not well suited to this role. Technically, coal-fired units cannot operate for extended periods at part loads of less than 50%. Further, they cannot be entirely shut and then restarted over periods of a few days, at least not regularly. Financially, some may be able to operate for extended periods at low overall capacity factors. If they did, however, some may have difficulty justifying more than routine maintenance costs, undoubtedly induced by duty cycles requiring rapid and large amplitude output variation. It is presumably such considerations which have led many critics of the NEG to suggest that it will lock in coal-fired generation at high capacity and block the transition of the Australian electricity supply system to a low emission future.

Fourth, by removing demand from the middle of the day, the steadily increasing capacity of rooftop solar generation will also increase the variability of the residual demand which dispatchable generators currently supply. The designers of the NEG appear to think that it will greatly constrain increases in wind and grid-connected solar generation after the LRET is built out in 2020. Such a limitation would serve to "protect" the role of existing coal fired power stations, by preventing further increases in the variability of the demand which dispatchable generators are required to meet. However, the NEG will not, without imposing some form of outright ban, be able to constrain the continuing growth of rooftop solar generation, which will continue to be an attractive investment for many electricity consumers, even without the rebate currently available through the Small Renewable Energy Scheme.

As a final comment, for long-time observers of Australian energy and greenhouse policy there is painful irony, and not a little apprehension in the facts that:

1. the NEG will incorporate environmental objectives relating to greenhouse gas emissions into the National Electricity Market Rules;
2. in doing so, numerous far-reaching changes to the Rules will have to be completed in two years or less, and
3. according to reports, the principal architect of the NEG is the Australian Energy Market Commission (AEMC).

For well over a decade, many individuals and organisations have tried to change the National Electricity Objective (NEO) to incorporate environmental objectives. The NEO is a statement, endorsed by COAG and embodied in the National Electricity Law, which determines the whole framework for the NEM Rules. To paraphrase, the objective is to promote efficiency in all aspects of the electricity industry operation, so as to enhance, in the long term interests of consumers, price, quality, safety, reliability, and security of supply of electricity.

All attempts to add an environmental objective to this list, and therefore to bring the pursuit of environmental objectives into the scope of the Rules, have been vigorously and effectively opposed by the AEMC. The AEMC has also, in its role as “the rule maker for Australian electricity and gas markets” become notorious for its slow processes to make any change to the existing Rules. It is hard to avoid the conclusion that, faced with an unavoidable need to make some changes in pursuit of emissions reduction, the AEMC has skilfully ensured that it will take the lead in determining how such changes are made and what the new Rules will be.

Appendix: Notes on methodology

Data on annual consumption of electricity, and seasonal peak demand, are for each of the six states. All other data are for the states constituting the National Electricity Market (NEM) only, i.e. they exclude Western Australia. 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.

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 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 September 2017 was about 5.9 TWh p.a., equivalent to 3.1% of the combined total.