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National Energy Emissions Audit
Electricity Update

August 2019

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

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Key points

- Wind generation across the NEM set a new record in July of 4,586 MW, (equivalent to the capacity of over two Liddell power stations), supplying 18% of total NEM generation at 9pm on 14 July.

- South Australia has always been more energy insecure compared to the eastern states and it is why the Heywood connector was the first interstate transmission line built in Australia.

- For nine of the last eighteen months, half of all energy supplied in South Australia has been from renewable generators, including rooftop solar.

- The South Australian system remains reliant on high gas generation for the stable operation of the supply system, as its currently configured, even when renewable generation is large enough to meet all demand in the state.

- South Australia is a test case for future scenarios of high penetration renewables and while AEMO continues to intervene in the market by either directing gas generators to run or directing windfarms to curtail output, or both, as it judges to be necessary to maintain system security, AEMO has acknowledged that, as it gains more experience it feels able to gradually reduce such interventions.

- South Australian electricity supply system provides real world evidence of how a new base load generator, such as a nuclear power station, could not be incorporated into a system with a high proportion of variable renewable generation. The best complement for high renewables is storage and a diversity (in location and type) of renewables.

- Liquid fuel security will continue to be a concern, given even if an Australian government blocked all exports of crude oil, local production would only be sufficient to meet one fifth to one quarter of total domestic petroleum fuel consumption.

INTRODUCTION

Welcome to the August 2019 issue of the *NEEA Electricity Update*, with data updated to the end of July 2019. The *Electricity Update* presents data on electricity demand, electricity supply, and electricity generation emissions in the National Electricity Market (NEM), plus electricity demand in the South West Interconnected System (SWIS). Since the start of 2018 we have been charting the rapid growth in wind and solar generation. There can be no doubt that Australia's electricity system is well along the road to a fundamental transition in terms of both the means by which electricity is generated and the system through which electricity is supplied to consumers. For this issue we have prepared some new graphs that show the transition over the more than twenty years since the National Electricity Market was launched, in December 1998. In addition, we include a particular focus on South Australia, where the transition is most advanced. Every few years possible risks to the security of Australia's access to petroleum fuels enters into the public debate, as has occurred over the past couple of weeks. As our contribution to the discussion, we have prepared a table which summarises where Australia sourced its oil imports last year.

OVERVIEW OF MAIN TRENDS

Demand for electricity

Annualised consumption supplied from the grid continued to fall during July in the NEM and in all NEM states except Victoria, where demand was effectively unchanged from June, as shown in Figure 1. The largest fall, in both absolute and relative terms, was in New South Wales. Of course no great conclusions can be drawn from a single month by itself, but July is simply the most recent month in a trend which has now been evident for a year. However, when electricity supplied from rooftop solar is taken into account, it can be seen that total consumption of electricity is not in fact decreasing, but is in fact is almost exactly constant over the past 12 months although, as shown in Figure 2, it did decrease in July.

Figure 3 is the winter 2019 update of the chart of seasonal peak trading interval demand in the NEM, plotted on a relative basis, compared with summer 2007-08. Winter peaks invariably occur just after sunset on a weekday evening in June or early July. The trading interval peak is the average of the six 5 minute dispatch interval demand figures, so is not the absolute system peak, though close to it. This year, the winter trading interval peaks in both New South Wales and Queensland occurred on Tuesday 4 June between 6.00 and 6.30 pm, referred to as the 18.30 NEM trading interval. The winter peak in the three southern NEM states occurred on Monday 24 June, also in the 18.30 trading interval in Victoria and Tasmania, which was also when the peak for the whole NEM occurred. The peak in South Australia occurred 30 minutes later, which was of course also the period between 6.00 and 6.30 pm in terms of local time. It can be seen in Figure 3 that the 2019 winter peak for the NEM was the highest since 2010, and was also amongst the highest ever in Queensland and South Australia, but not the other three NEM states.

Figure 1

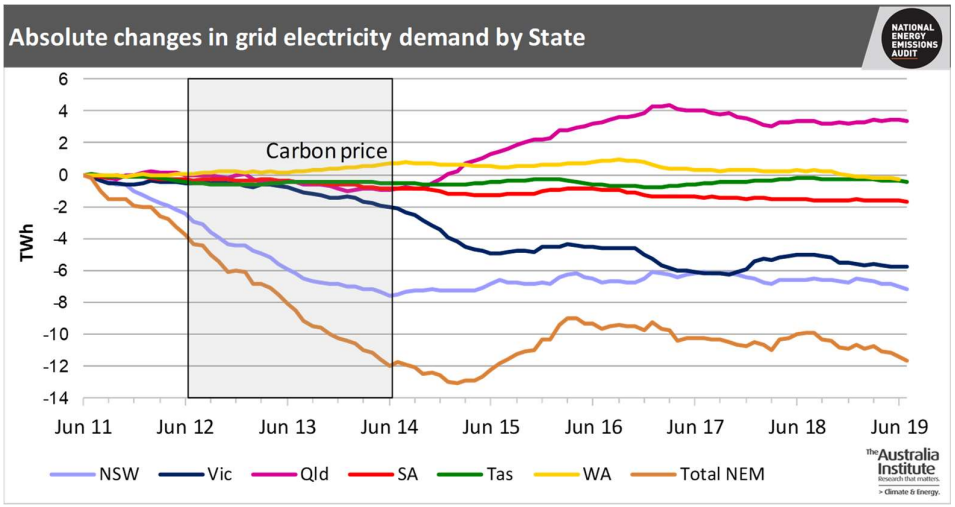


Figure 2

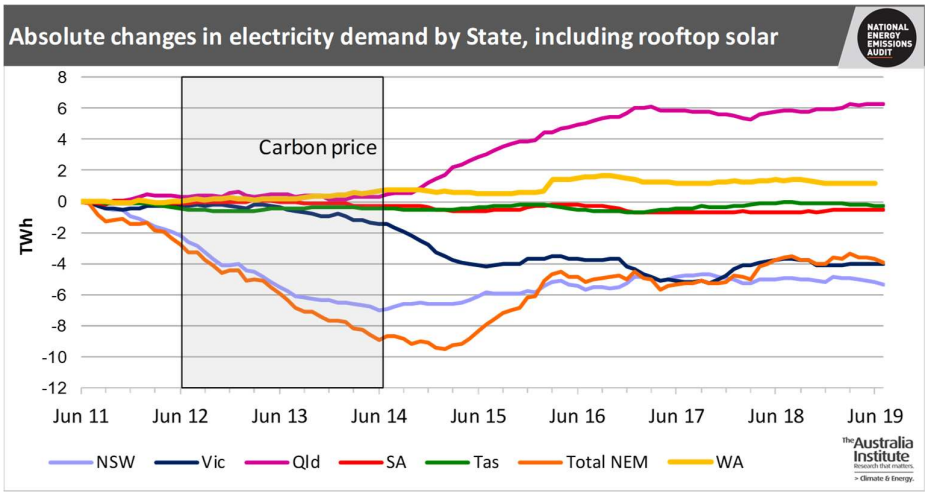
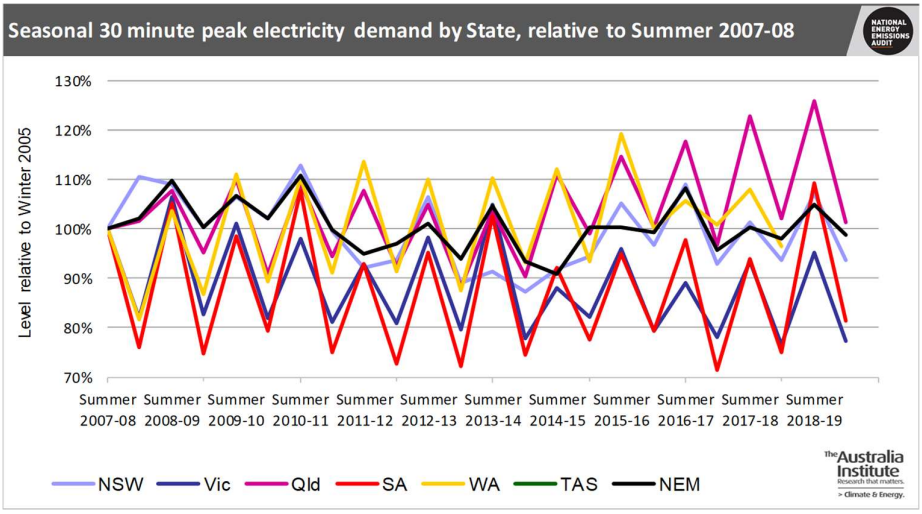


Figure 3



Generation and emissions

Figure 4 shows that supply from both black coal and brown coal power stations continues to decrease. As noted in the last NEEA Report, brown coal output is affected by the continuing availability of Unit 2 at Loy Yang A, which is expected to last until December, while hydro generation is constrained by ongoing drought conditions. Very strong growth in both solar and wind generation continues, as also, therefore, does the decrease in emissions, as seen in Figure 5.

Figure 4

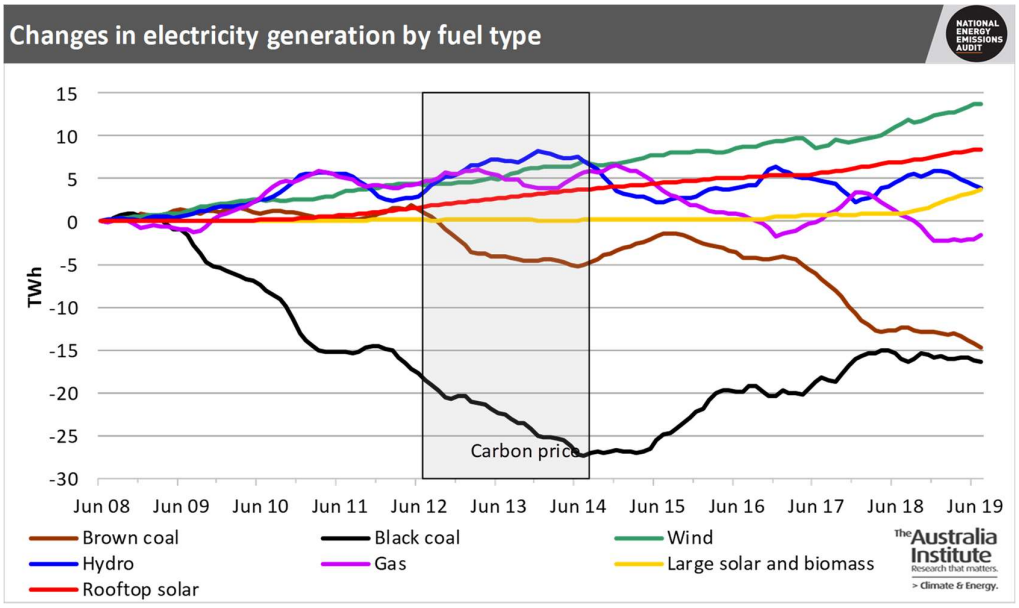
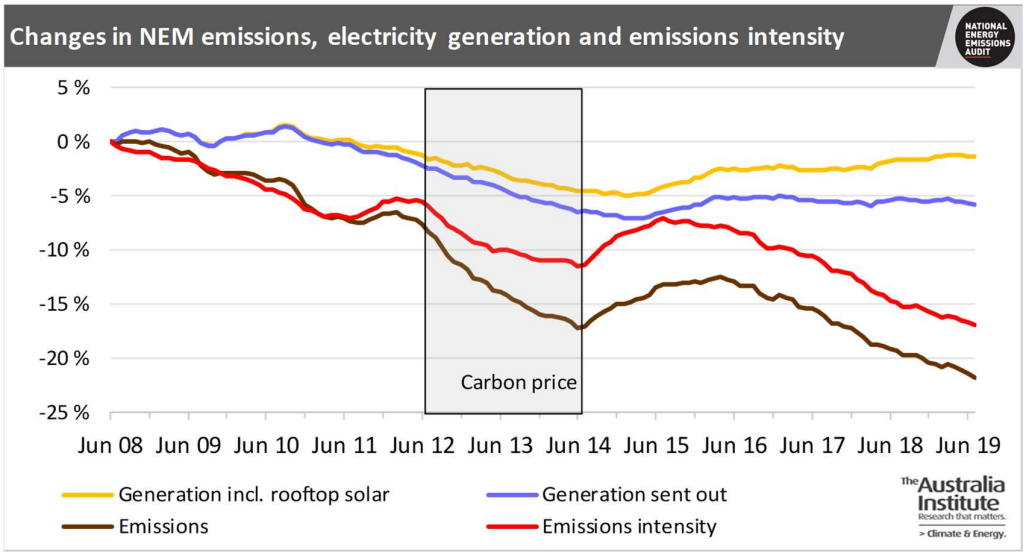


Figure 5



Renewable generation sets new records

In July, average monthly wind generation reached new record levels in both Victoria and New South Wales, as shown in Figure 6. Trading interval wind generation across the NEM as a whole also set a new record of 4,586 MW at 9.00 pm on 14 July, at which time it was supplying 18% of total NEM generation.

Figure 6

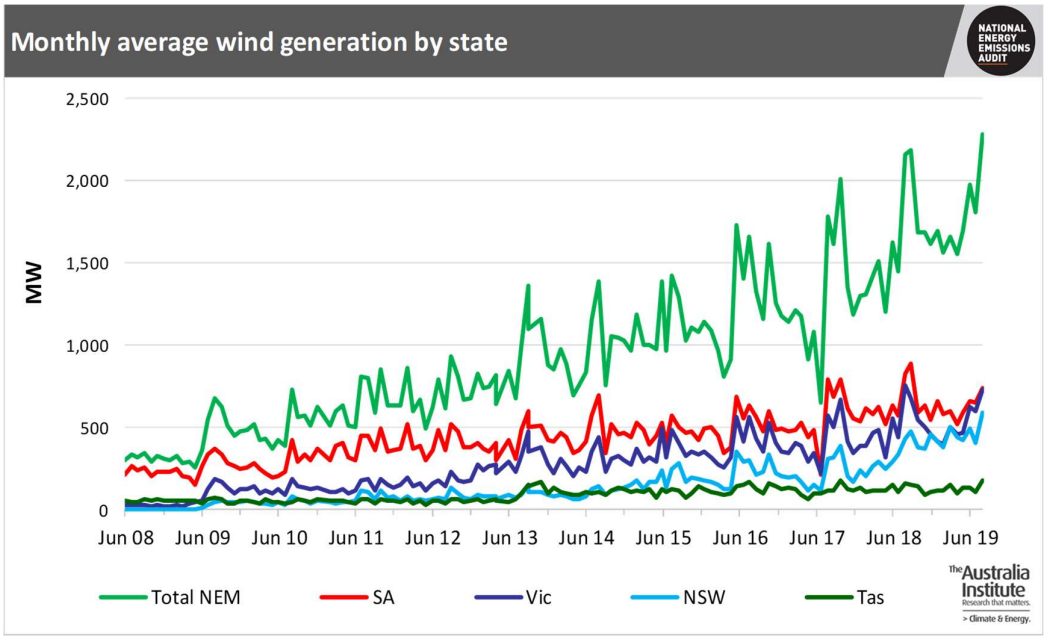
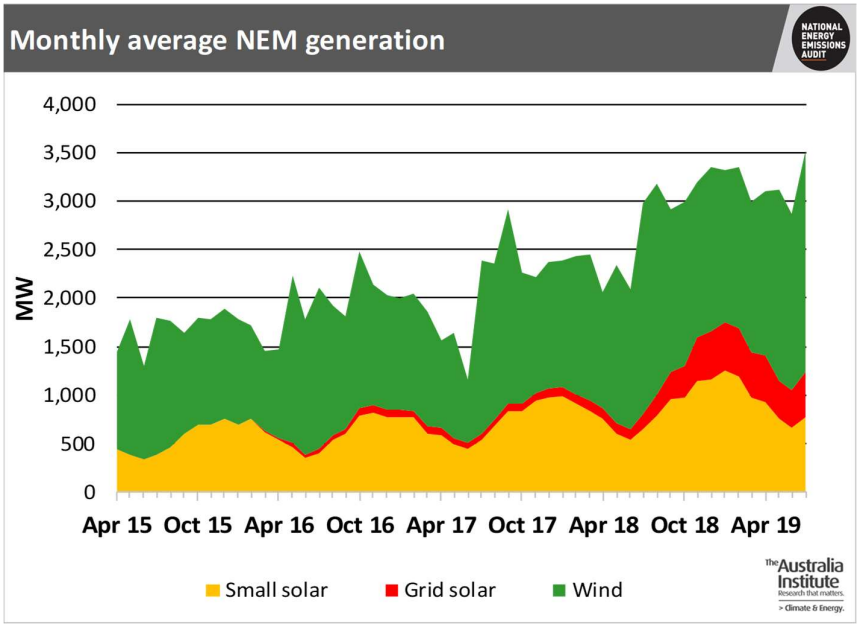
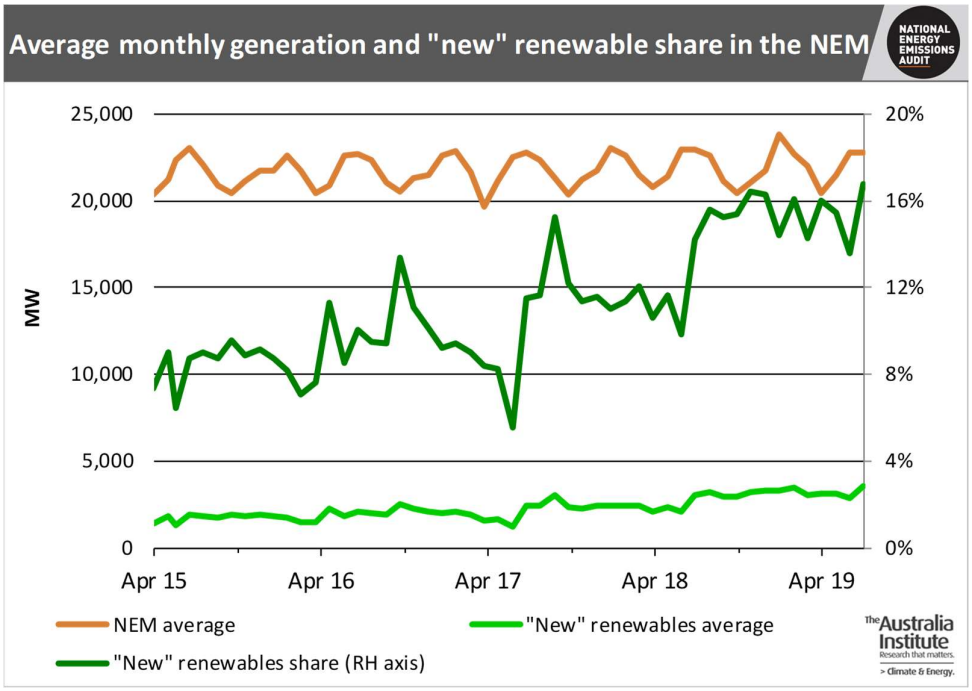


Figure 7



Record wind generation resulted in a record monthly average level of total “new” renewable generation (Figure 7), even though July is not a good month for solar generation. This in turn meant that “new” renewables, i.e. wind and solar, also achieved a record monthly share of NEM generation (Figure 8).

Figure 8

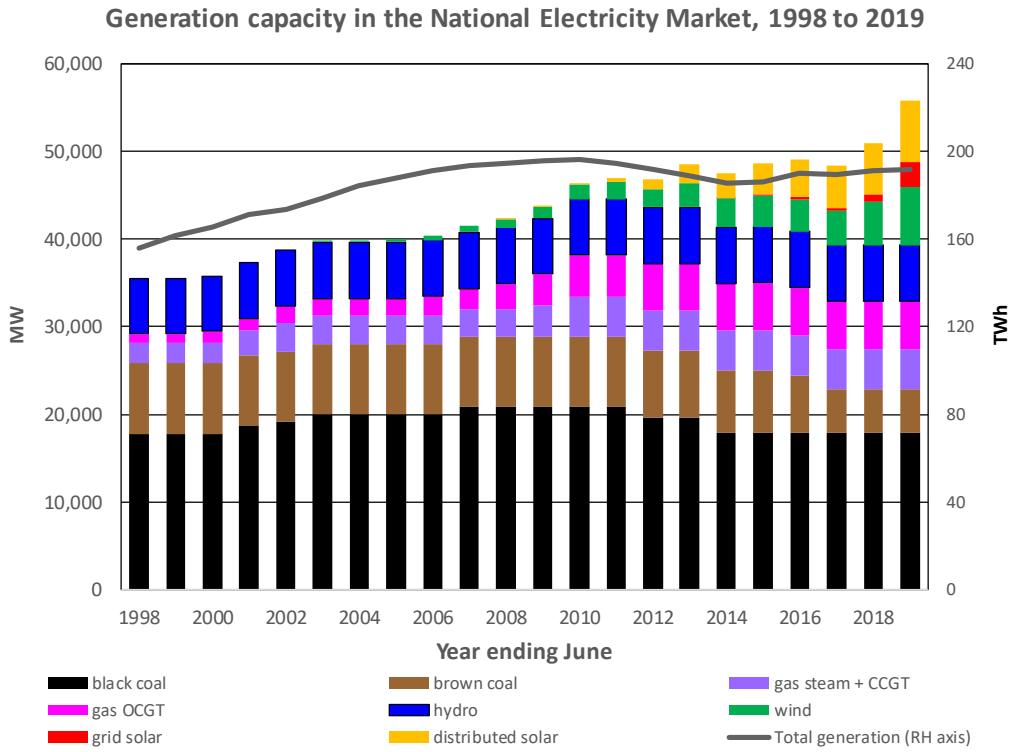


A FURTHER LOOK AT THE TRANSITION TO RENEWABLE GENERATION

Transition at the whole of NEM level

Figure 9 shows NEM generation capacity by type of generation at the end of each financial year sine June 1998. Figure 10 shows the total electrical energy supplied to the NEM system by each type of generation in financial year since 1999-2000. (Since the NEM started in December 1998, there is not a full year’s data for 1998-99.) Tasmania did not join the NEM until May 2005, when the Basslink cable was commissioned, but we have compiled a consistent and complete data series by adding data for Tasmania from other sources for the years 1998 to 2005.

Figure 9

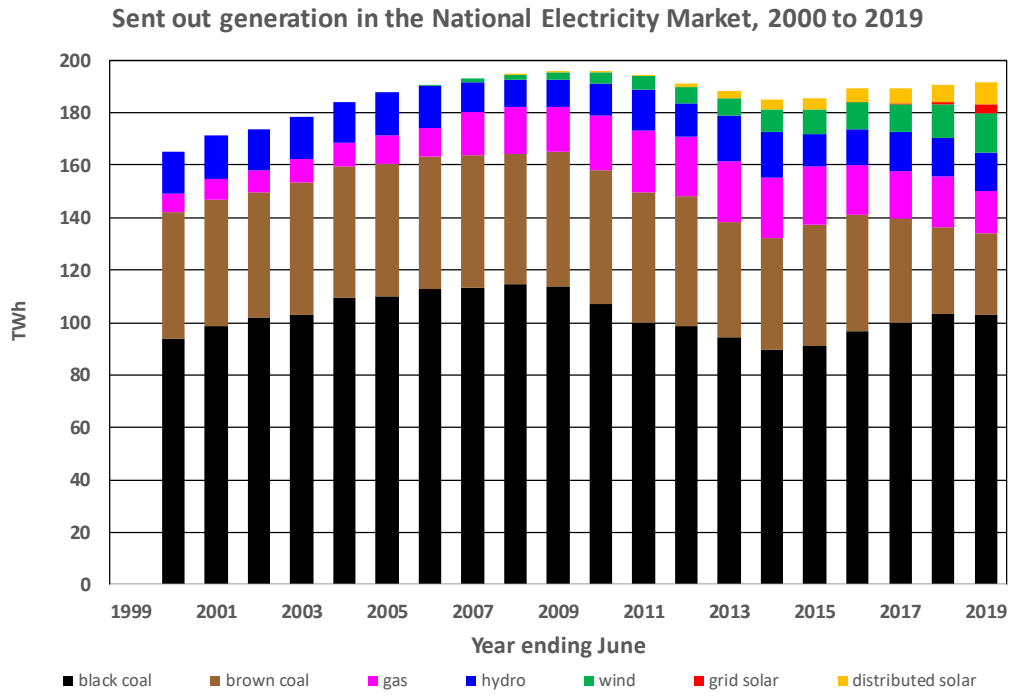


The full 20 year period is best understood by separating it into four periods, each of about five years duration. From 1999 to 2004 annual demand for electricity continued to grow at about the same rate as had prevailed throughout the 1990s. New South Wales and Victoria had much more generating capacity than they needed to meet this demand, a legacy of the huge power station construction program undertaken during the 1980s and early 1990s, which saw the construction of Eraring, Bayswater, Mount Piper, Loy Yang A and Loy Yang B coal fired stations. By contrast, Queensland and South Australia were short on capacity, but started the period with three new high efficiency super-critical coal fired power stations under construction in Queensland, and two combined cycle gas stations being built in South Australia. With the exception of one private power station, Milmerran (the only large coal fired power station ever built by private investors in Australia in the past eighty years), all these new plants were conceived, designed and supported by the state government owned electricity authorities before the NEM was in place.

During the second period, from 2005 to 2009, growth in annual consumption began to slow, but this change was not recognised by the industry. In Queensland, one of the government owned generation businesses, finished building the super-critical Kogan Creek, the last large coal fired power station built in Australia. Also in Queensland, a number of private investors built gas fired power stations, both combined cycle and open cycle, with the hope of taking advantage of the marker created by a state government measure to support the emerging coal seam gas industry by mandating that all licensed electricity retailers source a minimum share of their wholesale purchase from gas generators. A smaller number of new gas generators

were also built in each of the other states, in the expectation (or hope) that anticipated new policies to reduce greenhouse gas emissions would make them a profitable investment. Simultaneously, new windfarms, supported by the LRET, started to become important, particularly in South Australia.

Figure 10



The third five years, from 2010 to 2014 was a period of turmoil. Demand growth turned negative, but massive investments in augmented network capacity were approved by the regulator, leading to massive increases in the price of electricity. Two of the older large coal fired power station in New South Wales were closed, unable to compete with imported electricity supplied by coal fired stations with access to lower cost coal resources in both Victoria and Queensland. In addition, a price on emissions came and went, giving a one-off boost to the profits of Hydro Tasmania and Snowy Hydro.

Since 2015, ups and downs of aggregate supply and demand have become markedly less turbulent. Demand for grid supplied electricity has been almost completely flat, as modest increases in consumption have been met by rapidly growing rooftop solar generation. At the grid level, competition from wind generation has contributed to the closure of old brown coal power stations in Victoria, and uncertainty hovers over the future of several others, both brown and black coal fuelled, as growth in both wind and solar generation has accelerated. Gas generation is severely handicapped by large increases in the wholesale price of gas. Despite gas production doubling in the last five

years in Australia, it has almost completely been channelled into Australia's increasing LNG exports. There is no issue with gas supply but direction and a domestic reservation policy for NEM states will not address the high prices. If the reservation policy is applied prospectively it will tap into more expensive greenfield sites. We expect gas to remain expensive in Australia.

Despite the uncertainty of the high level policy environment, however, both the fact of the transition, and the direction in which it is heading, have become clear at the industry level.

The transition in South Australia

Figures 11 and 12 show respectively capacity and generation over the same 20 year period as used for the two previous figures, but for South Australia only. Figure 12 clearly shows that, when the NEM started, South Australia was a large net importer of electricity from Victoria (consumption was much higher than generation). This was by no means an accident. South Australia had always been aware that, lacking the large low cost coal resources of the three major eastern states, electricity generation was unavoidably more expensive. With only two major power stations, one coal and one gas, it was also vulnerable to supply disruptions, which happened in June 1980, when, to quote from ElectraNet:

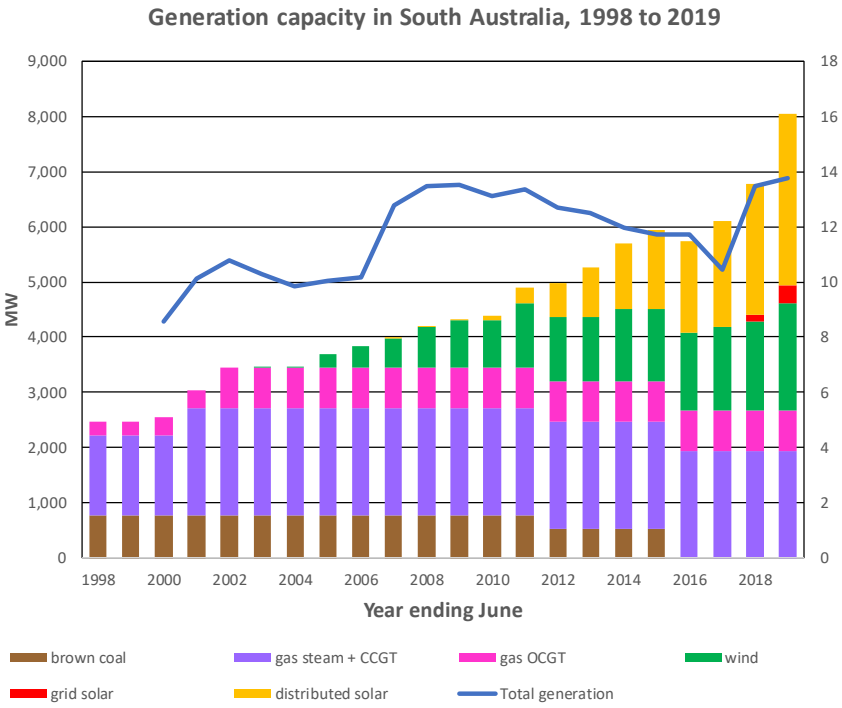
> "The natural gas pipelines supplying the [Torrens Island] Power Station were both shut off through a mistake during a routine test by the gas supplier."

Without boiler fuel, the whole power station, supplying well over half the state's demand, shut down, triggering a complete system collapse and state-wide blackout. Fortunately, on that occasion, unlike the more recent and notorious blackout, the black start systems operated as intended, and supply was restored after, according to the history, several hours.

It was for these reasons that during the 1980s the state strongly supported connecting its transmission system to Victoria. The Heywood interconnector, the first interconnector between Australia's electricity supply systems, was commissioned in 1988. The benefit, in the form of lower wholesale electricity prices, was obvious for some years. In 2007 and 2008 wholesale prices rose sharply, as they did in all NEM states, and then fell again until the arrival of the carbon price in July 2012. As the growth in wind generation helped to push wholesale prices down again, Victorian generators were able to out-compete coal and gas generators in South Australia, and net imports increased strongly. The economics of South Australia's Northern power station, in particular, were undermined by the combination of growing wind

generation and competition from Victorian generators, resulting in its closure in May 2016. This was followed in March 2017 by the closure of Hazelwood power station in Victoria, together with two smaller brown coal power stations.

Figure 11



This ushered in a dramatic change. The combined effect of much reduced quantities of low marginal cost brown coal generation Victoria, increased wind generation and increased gas generation, coinciding with a dramatic rise in wholesale gas prices, saw both a massive increase in spot wholesale prices for electricity and, in some months, a switch from net importing to net exporting of electricity, as shown in Figure 13. This graph shows the steady growth in both renewable and gas fuelled generation.

During nine of the past eighteen months, as Figure 14 shows, supply from renewable generators, including rooftop solar, has equalled, in total for the month, more than 50% of total electricity generated in South Australia. In nine of the past twelve months total renewable generation equated to more than 50% of total consumption, and in August and October last year it was more than 60%.

Figure 12

May 2016.

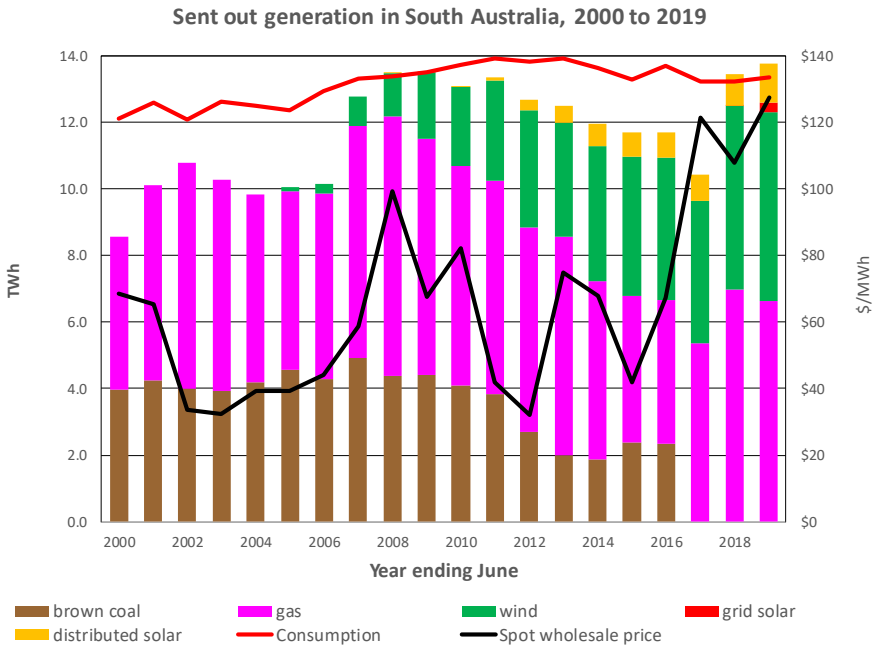
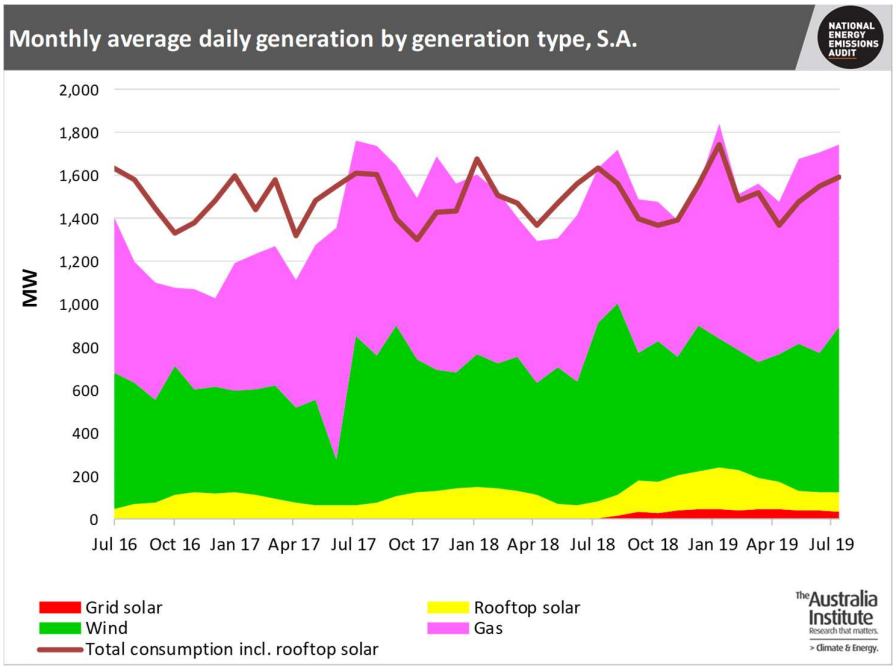


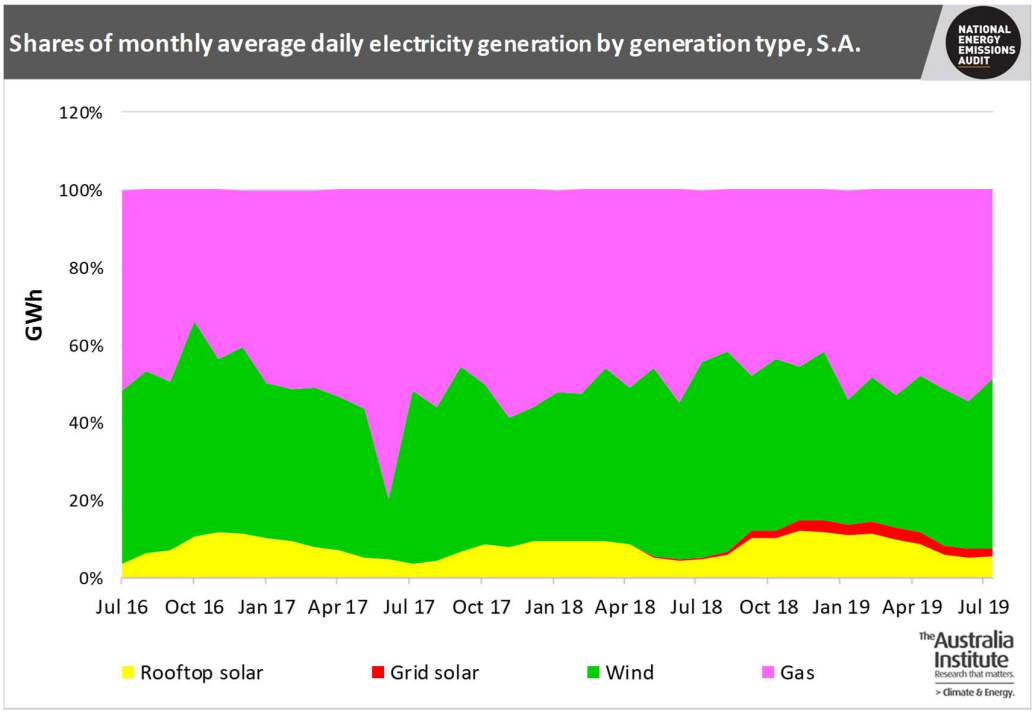
Figure 13



Gas generation remains at high levels because stable operation of the supply system as currently configured requires some gas generators to be on-line at all times, even when renewable generation is large enough to meet all demand in the state. On a number of occasions over the past two years, AEMO has intervened in the market by

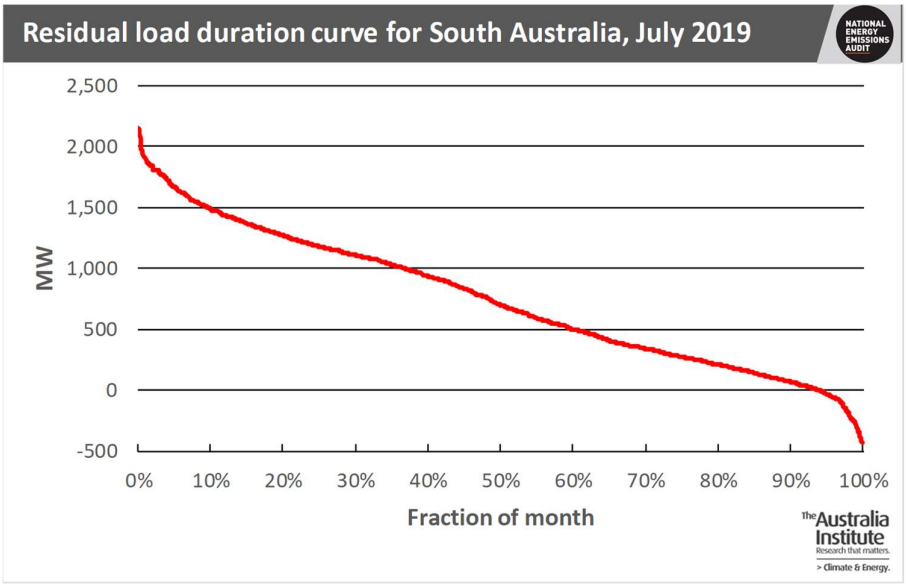
either directing gas generators to run or directing windfarms to curtail output, or both, as it judges to be necessary to maintain system security. AEMO has acknowledged, however, that, as it gains more experience in operating a system with a proportion of variable renewable generation, it feels able to gradually reduce such interventions.

Figure 14



Examining the operation of the South Australian electricity supply system provides real world evidence of how a new so-called base load generator, such as a nuclear power station could not be incorporated into a system with a high proportion of variable renewable generation. Figure 15 is a trading interval residual load duration curve for South Australia during July. Residual load is the consumer demand (load) for which, at the time, there is insufficient renewable generation, meaning that supply had to be provided by either gas generators or imports form Victoria. The curve shows that during 88 trading intervals (44 hours in total), all demand in the state could be supplied by wind and solar, with some left over to export. What was the "base load" in South Australia during July? The answer of course is that there was no "base load" and there never will be again. Eliminating "base load" is what the transition to a low emission renewable generation based electricity supply system is doing, in South Australia, in the rest of Australia, and round the world. The complement to variable renewable generation is not so-called "base load" generation (a meaningless term), but energy storage in some of its many forms and spatial/climatic diversification of renewable generation.

Figure 15



AUSTRALIA'S DEPENDENCE ON IMPORTED PETROLEUM

At the beginning of August the government brought the issue of Australia's dependence on imported petroleum imports back into the public debate on energy and security policy. To help inform debate, the table below provides a summary of Australia's import dependence in 2017-18, and the source countries on which it depended. All data is taken from the longstanding official publication *Australian Petroleum Statistics*.

There are several interesting features.

- Only 10% of Australia's petroleum requirements (17% of crude oil imports) were sourced from the Persian Gulf. There were no crude oil imports from Saudi Arabia, Qatar, Iraq or, of course, Iran.
- On the other hand, although it cannot be directly deduced from the information shown, refineries in the three major sources of imported products, Korea, Singapore and Japan, do depend heavily on crude oil imported from Gulf countries.
- Refineries in these countries, and several other countries in east and south east Asia, are the source of almost half of Australia's total consumption of petroleum fuels.
- Even if an Australian government stopped exporting its crude oil, production would be sufficient to meet only between one fifth and one quarter of total domestic petroleum fuel consumption. Note that, quite apart from the economic and legal

implications of such an action, Australia's four remaining oil refineries may not be technically capable of using such a high proportion of crude oil with the particular chemical characteristics of Australian crude oil.

Sources of Australian petroleum imports, 2017-18

Crude oil		**Refined petroleum products**	
Imports + domestic production	37,851 ML	Imports + domestic production	64,978 ML
Country	**Share**	**Country**	**Share**
Malaysia	18.6%	Korea, Republic of (South)	15.8%
United Arab Emirates	10.1%	Singapore	14.8%
Indonesia	5.0%	Japan	7.8%
Nigeria	4.5%	Malaysia	4.3%
New Zealand	2.9%	India	4.1%
Brunei Darussalam	2.8%	China	3.2%
Algeria	2.7%	United States of America	1.8%
Gabon	2.7%	Indonesia	1.0%
Congo	2.2%	Netherlands	0.5%
Vietnam	2.2%	United Kingdom	0.5%
17 other countries	5.5%	33 other countries	2.2%
Domestic production	40.8%	Domestic refinery production	44.1%
Exports	-34.4%	Exports	-8.9%

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.