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NATIONAL ENERGY EMISSIONS AUDIT

National Energy Emissions Audit Electricity Update

November 2019

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

Author: Hugh Saddler

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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

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KEY POINTS

+ Coal share of generation in Queensland hit its peak in October 2018 (last reached in 2005) and is now being steadily eroded by growing supply from large renewable generation, particularly solar farms.

+ Victoria coal generation is at its lowest levels since the start of the National Electricity Market 21 years ago, due mainly to the closure of Hazelwood and several smaller stations and, at present, to the continued unavailability of unit 2 at Loy Yang A.

+ Since total annual generation of coal peaked in January 2009, black coal generation has dropped 9%, brown coal generation has fallen 41%, gas generation has increased by only 3% and overall generation has fallen 9%. The gap has almost entirely been filled by renewables.

+ On 26 October during the 30 minute trading period from 11.00 to 11.30 am total renewable share hit a high of 47.3% of NEM generation.

+ NEM consumption is greater during winter months (defined as May to August) rather than summer months (December – March), but summer suffers greater electricity peaks (mainly because air conditioning is immediate whereas space heating is often a slower, smoother demand).

+ The pumped hydro in Queensland, Wivenhoe is being more readily used to take advantage of cheap solar generation during the day. This will only continue to ramp up as the ownership of Wivenhoe transfers to the state-owned clean energy corporation CleanCo.

+ Snowy 2.0 would provide roughly ten times the energy storage capacity of its current facility, Talbingo. If it proceeds, Snowy 2.0 will be Australia's largest single investment in electricity supply infrastructure for many years, however, it is worth asking whether it will offer the best public return on investment of all the possible options for Australia's electricity system transition.

+ During each of the months of August, September and October 2019, new renewable generation, meaning wind and solar generation, both grid scale and rooftop, reached new record monthly levels, expressed in both absolute terms (average MW during the month), and as a share of total generation.

INTRODUCTION

Welcome to the November 2019 issue of the *NEEA Electricity Update*, with data updated to the end of October 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.

This issue includes several new graphs which look in close detail at the transition, as it is evolving in New South Wales, Victoria and South Australia. As responsibility for the Wivenhoe pumped storage in Queensland passes to CleanCo, a new state government owned commercial generation entity, we also look at how its previous owners, and also the owners of the two other pumped storage schemes in the NEM, have been making much more use of these plants in recent months.

OVERVIEW OF MAIN TRENDS

Demand for electricity

Annualised consumption supplied from the NEM grid continued falling steadily in October, for the fourth month in succession, as shown in Figure 1. Consumption fell, or was almost exactly flat, in every individual state except Victoria, where consumption is increasing slowly. The steady fall in Western Australia also continued. However, when rooftop PV is added to grid consumption, as in Figure 2, there was a small growth in NEM consumption.

Figure 1

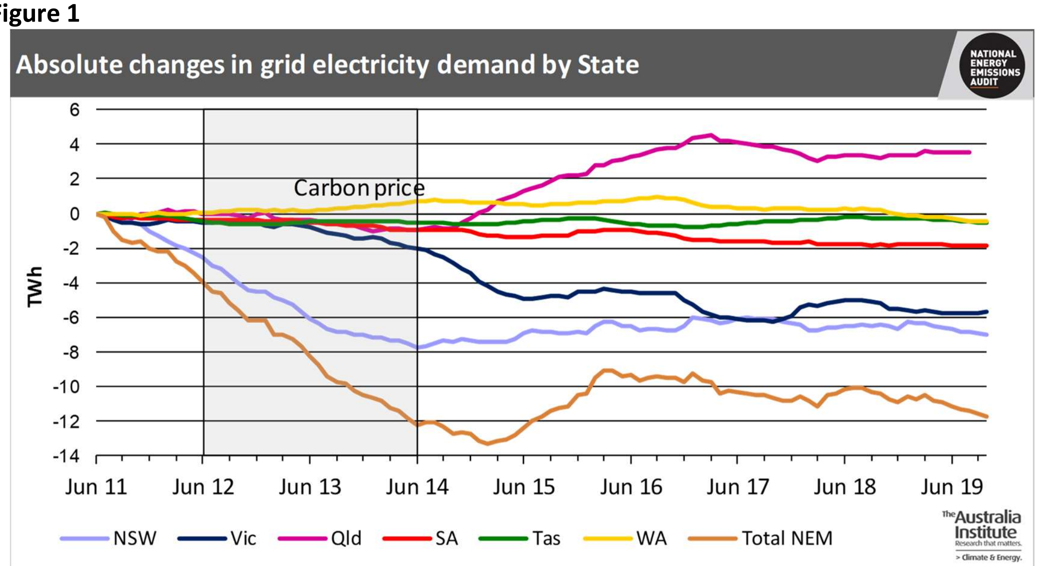


Figure 2

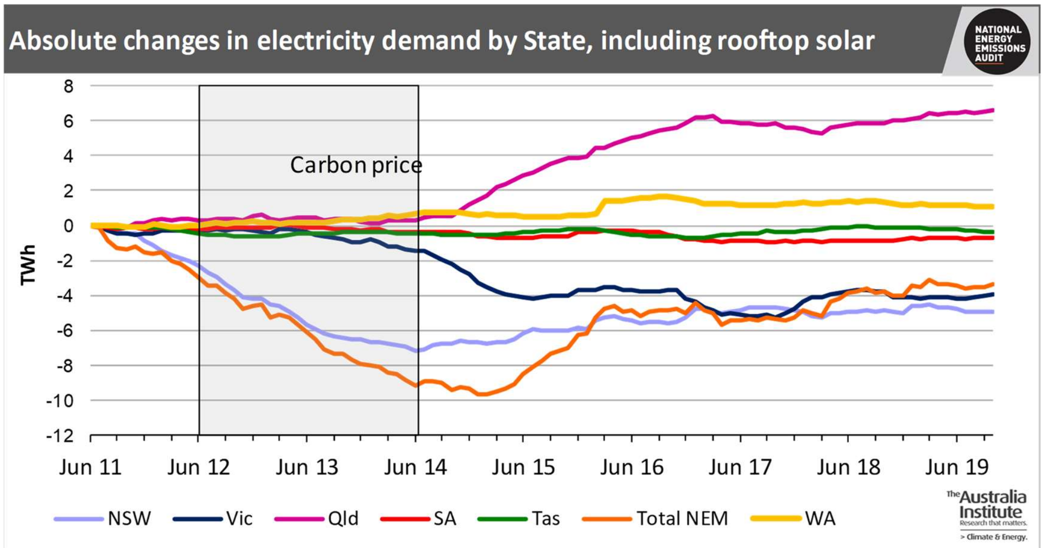


Figure 3

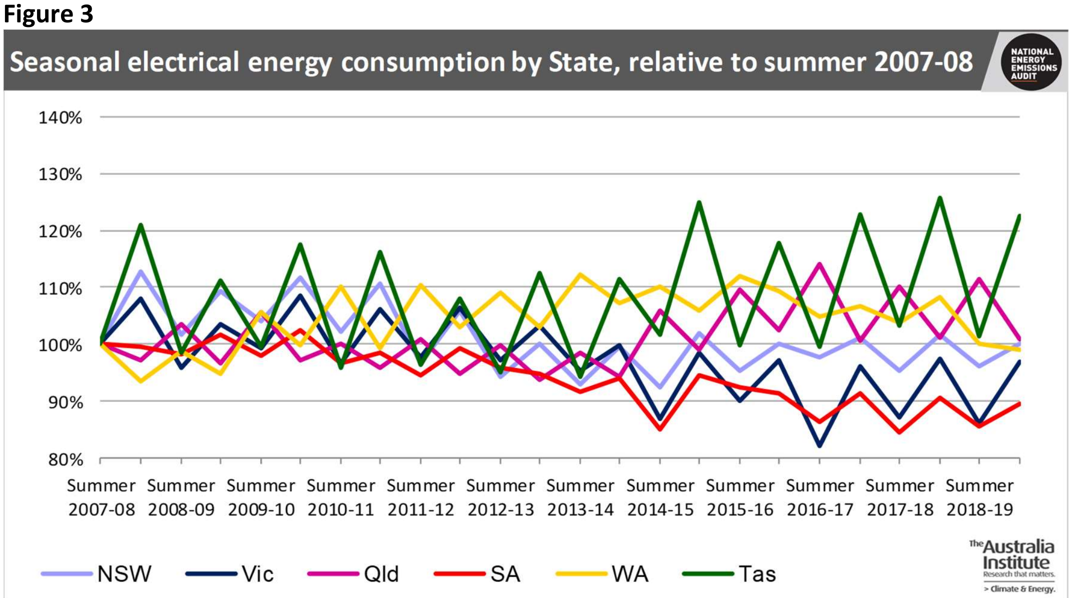


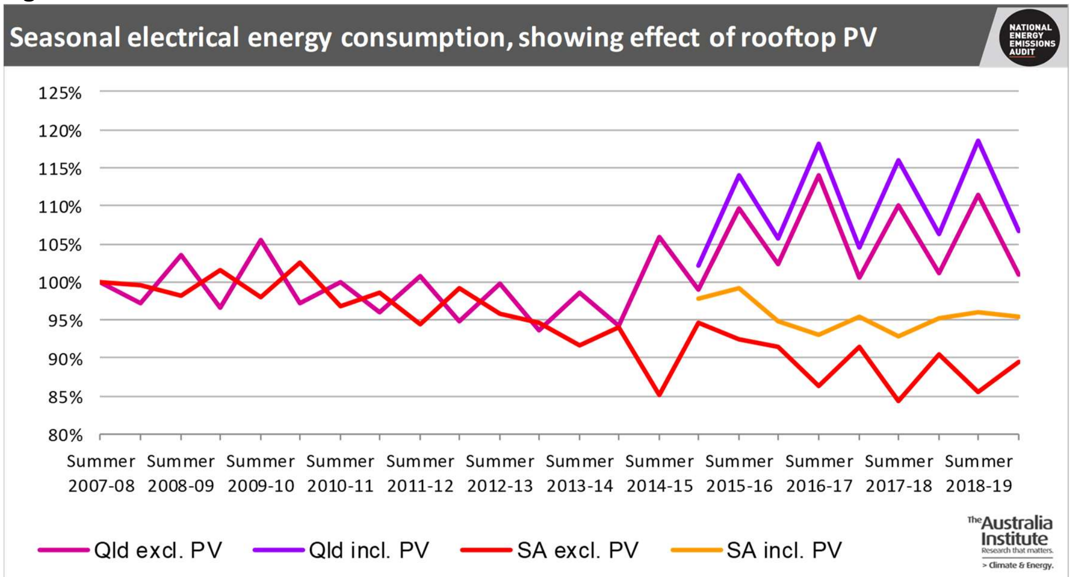
Figure 3 shows seasonal consumption of electrical energy from the grid in each state. For convenience, seasons are defined in terms of whole months, with December to March defined as summer and May to August defined as winter. Throughout Australia, and without exceptions in any years, these eight months record higher electricity consumption than the remaining four months of the year. This, incidentally, is why owners/operators of coal fired power stations always try to schedule maintenance to be done during April, September and October.

Note that in all states except Queensland (and with the exception of a few past summers in South Australia), more energy is used during the four winter months than during the four summer months. In other words, the consumption of electricity for heating and lighting during winter is consistently larger than consumption for cooling and lighting during summer. This is seen even in Victoria, where well over two thirds of houses, and many commercial premises, use gas for heating including heating water. This difference between winter and summer is in contrast to the short term peaks of demand, which we most recently discussed in the August NEEA Report. Peak demand in every state except Tasmania almost always occurs on a very hot day in summer, because use of air conditioners is much more "peaky" than use of space heating.

The distinction between total energy consumption and peak demand is crucially important for electricity system policy and planning. Energy consumption is what mainly affects emissions, the economics of power station operation, and the total electricity bills paid by consumers. But it is peak load which mainly affects the economics of transmission and distribution, and the likelihood of supply shortfalls and the consequent disruption which they can cause.

Figure 4 is particularly interesting in this context. It adds to the lines in Figure 3 for Queensland and South Australia, the two states with the highest relative capacity of rooftop solar installations, an additional line which includes estimated energy supplied by rooftop PV (data for which has been available only since January 2015). The marked difference between the two states is striking. In Queensland, rooftop supply adds almost uniformly to grid consumption throughout the year, with somewhat more added, of course, in summer than in winter, because of longer daylight hours and higher sun angle. In South Australia, rooftop solar also adds to consumption throughout the year, but adds markedly more in summer than in winter because of the more southerly latitude of the state. However, in two of the last four summers the effect of adding supply from rooftop solar was so large that it meant that more energy was used, in total, in the summer months than in the winter months. It is hard to explain this change except by assuming that consumers with rooftop solar feel able to use more air conditioning than if they were buying all the electricity they required from the grid. This could mean any or all of running an existing air conditioner for longer periods, running it at a lower temperature set point, air conditioning more rooms in a house, installing a new, bigger air conditioner, or installing one to replace existing evaporative cooling, or no air conditioning at all. Using economic terminology, the data suggest that in South Australia use of air conditioning is, at the margin, a discretionary expenditure, whereas in Queensland it is largely non-discretionary.

Figure 4



Generation and emissions

Figure 5 shows a sharp drop in supply from black coal power stations and a continuing decrease in output from the three brown coal power stations. Black coal output in New South Wales fell sharply, as Mount Piper power station continues to be severely constrained and one unit at Bayswater is out for a major upgrade. In Queensland, annual coal generation appears to have peaked in the year to October 2018, when it reached the highest level since October 2005. The coal share of generation in Queensland is now being steadily eroded by growing supply from large renewable generation, particularly solar farms. Meanwhile, in Victoria, the continued unavailability of unit 2 at Loy Yang A saw brown coal generation drop to its lowest annual level since the start of the NEM, almost twenty one years ago.

Gas generation has followed an up and down path since 2008. During the first few years of the period, continued growth was driven by the Queensland state government policy, which required electricity retailers in the state to source a defined minimum share of their wholesale supply from gas generators in the state. For a few years after that policy was repealed by the Newman Liberal National Party government, gas generation remained at high levels as it was able to use so-called "ramp gas" – gas available cheaply for a short period between gas well completion and the completion of the new LNG plants, to which the gas could be supplied at much higher prices. Gas generation is now handicapped by the high wholesale price of gas in markets right across the NEM, and its use over the foreseeable future will be mainly determined by its role in off-setting the variability of wind and solar generation.

Hydro generation has followed a similarly varying path, affected by year to year variant in water availability and, for two years, by the economic advantage it gained by the price on emissions. Supply from other renewable generation has of course grown strongly, if not always smoothly, because of the erratic course of politics and policy over the period.

Figure 5

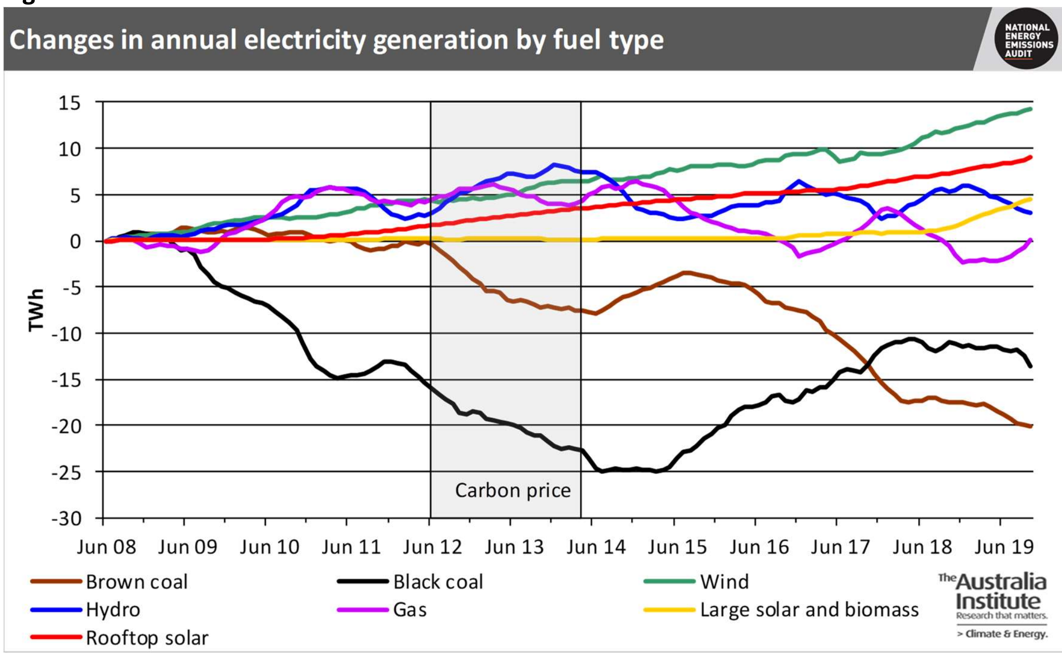
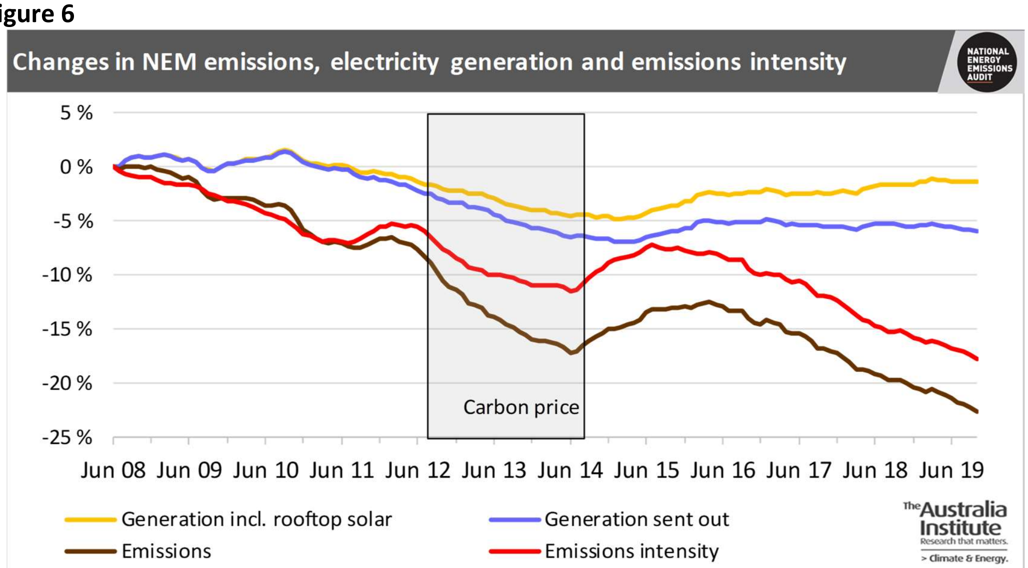


Figure 6



The overall result, as shown in Figure 6, is that total generation has fallen very slightly, as required to meet demand, whereas emissions and emissions intensity has fallen sharply. Overall, since total annual coal generation in the NEM peaked, in the year to January 2009, at exactly the same time as total annual NEM generation also peaked, the following changes have occurred:

Table 1: Electricity generation changes since 2009

Generation type	Change		
		TWh	Per cent
Black coal	decrease	-14.2	-9%
Brown coal	decrease	-20.8	-41%
Gas	increase	0.6	3%
Hydro	increase	2.7	25%
Grid biomass	decrease	0	-5%
Wind	increase	13.6	550%
Grid solar	increase	4.5	From zero
Total NEM generation	decrease	18.1	-9%
Rooftop solar	increase	9.0	From zero
Total electricity consumption	decrease	-9.1	-5%

The decrease in consumption has arisen in part from structural change in the economy, most notably the closure of the Kurri Kurri and Point Henry aluminium smelters, and in part from increases in the efficiency with which electricity is used. The smelter closures alone delivered almost all of the 9 TWh reduction. Efficiency increases have been enough to offset the effects on electricity consumption of growing population and economic activity, but could, and should, have been much larger, as we discussed in the September 2019 *NEEA Report*.

SPECIAL TOPICS

An update on renewable generation in the NEM

During each of the months of August, September and October 2019, new renewable generation, meaning wind and solar generation, both grid scale and rooftop, reached new record monthly levels, expressed in both absolute terms (average MW during the month), and as a share of total generation, including rooftop solar. These achievements are shown respectively in Figures 7 and 8. The share reached during October was 19.0%.

These record levels of output have been achieved despite the widely reported output curtailments imposed on a number of wind and grid solar generators, particularly in South Australia, and despite the lengthy delays in grid connection approval faced by many new projects, particularly in Victoria.

Figure 9 shows daily average generation in the NEM from all types of generation, during the period from 1 August to 10 November. The highest daily share of variable renewable generation, i.e. combined wind and solar generation, was 28.9% of 26 October, and during the 30 minute trading period from 11.00 to 11.30 am, the share reached 45.2%. Adding the relatively small hydro output at that time brought the total renewable share up to 47.3%.

Excluding both rooftop solar and hydro from the calculation, i.e. considering only variable generation supplied into the NEM grid, the highest trading interval share on that day was 23.3%. Total renewable generation was higher still on 7 November, which, like 26 October, was very windy and sunny across most of the NEM, but since this was a weekday, not a weekend, the share of renewable generation was slightly lower.

Figure 7

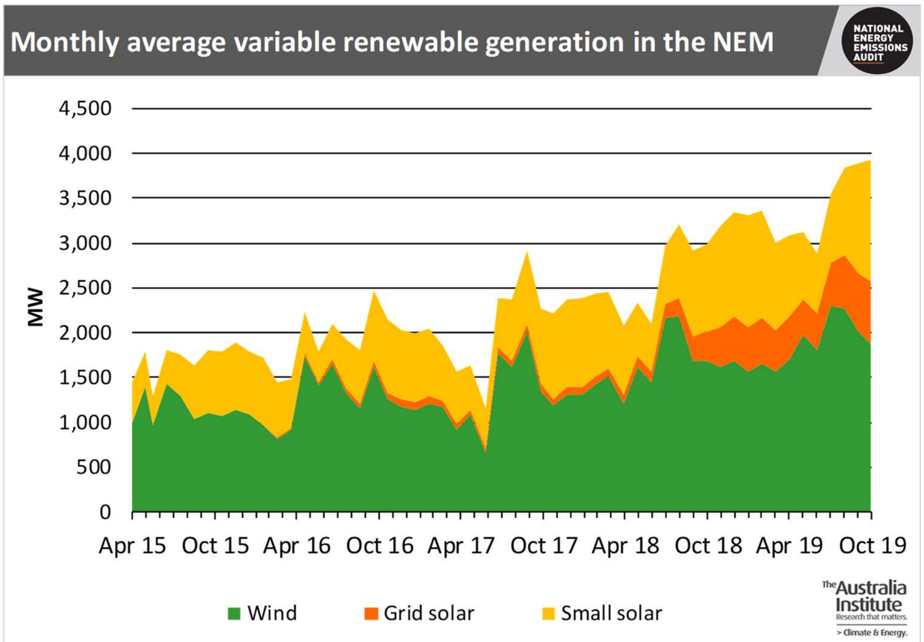


Figure 8

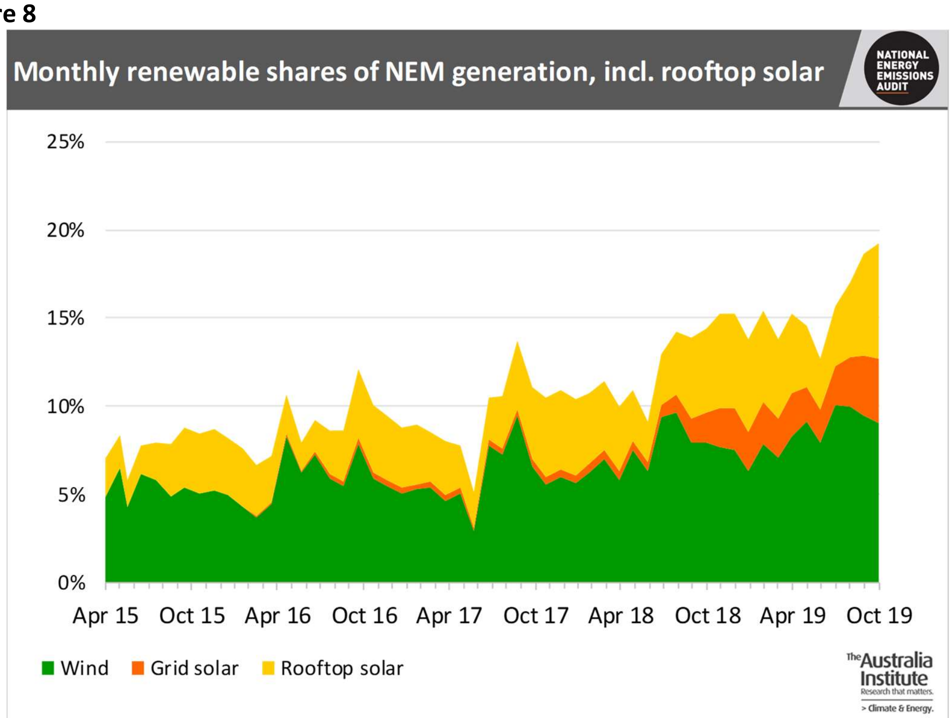
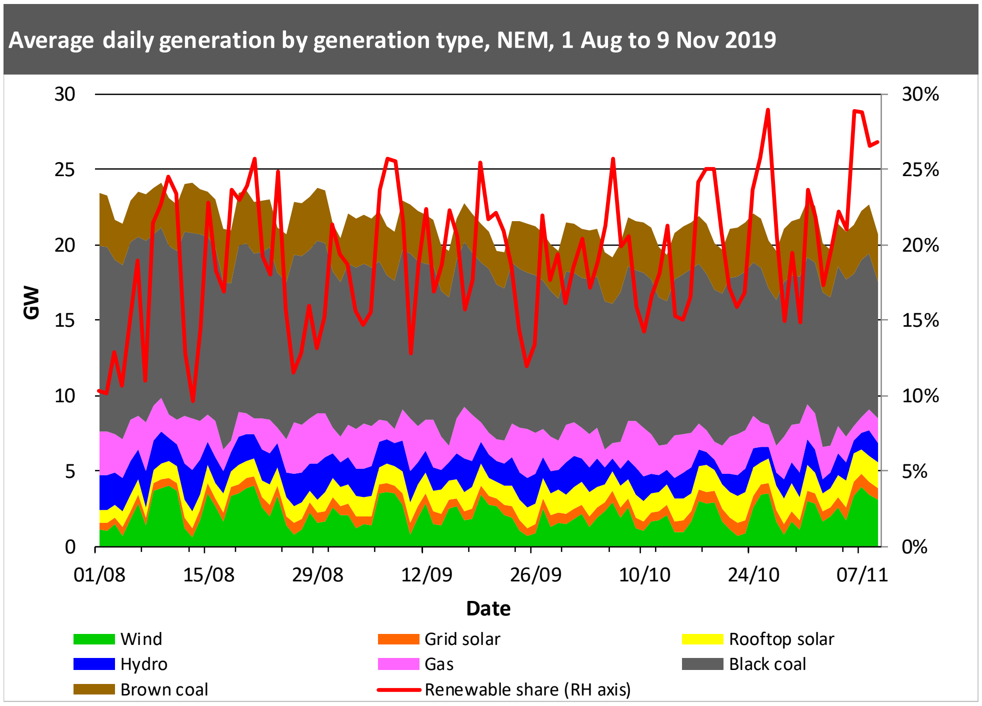


Figure 9



How is pumped storage in the NEM being used?

Everyone recognises that as wind and solar generating capacity continue to grow, more storage capacity will be needed, so that the availability of electricity can be time shifted, from periods of maximum wind and solar generation to periods of maximum demand. Australia has three pumped storage hydro schemes. Talbingo (sometimes called T3), which forms part of the Snowy scheme, is the oldest, and largest, completed in 1974. It now has a total capacity of 1,800 MW and a pumping capacity of about half that. The Shoalhaven scheme, also in New South Wales and completed a few years later, has a capacity of 240 MW, and was designed to function as both pumped storage for electricity and as a standalone pump to operate as part of the water supply to metropolitan Sydney. Wivenhoe, near Brisbane, is a "pure" pumped hydro scheme with a total capacity of 500 MW. It was completed in 1984 and operates within the Queensland region of the NEM.

As can be deduced for the completion dates, all three of these schemes were built by the relevant publicly owned electricity generation and transmission authorities (respectively, the Snowy Mountains Authority, the Electricity Commission of New South Wales (Elcom) and the Queensland Electricity Commission (QEC)). The schemes were intended to operate on a daily cycle, pumping overnight when demand was low, and generating during the morning and evening peak periods. To put it another way, they were intended to create so-called base load, thereby smoothing out demand on the New South Wales and Queensland coal fired power stations, reducing the need for them to ramp up and down to meet demand. Coal fired steam generation is not a technology well suited to frequent ramping, which increases fuel consumption per unit of output and also increase maintenance costs, all else being equal. At the time the pumped storage systems were built there were no gas fired peaking plants in either state.

Corporatisation of the various supply authorities during the 1990s, requiring them to operate like profit maximising businesses, was followed by the establishment of the National Electricity Market, the completion in 2001 of the major inter-connector between Queensland and New South Wales, and the construction of gas fired peaking power stations. The combination of these changes fundamentally modified the economic and technical environment within which these three schemes operated.

Figures 10, 11 and 12 show how Talbingo, Shoalhaven and Wivenhoe, respectively, have been used over the past seven years. For a long time, Talbingo, owned and operated by Snowy Hydro, did virtually no pumping, and thus no energy storage, meaning that it operated mainly as a conventional power station, using water coming down the Tumut River from T2 power station to generate.

Figure 10

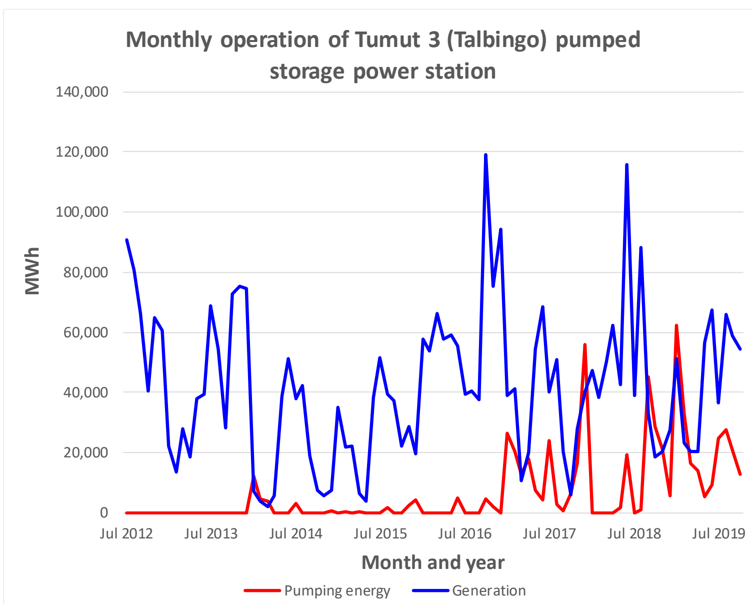


Figure 11

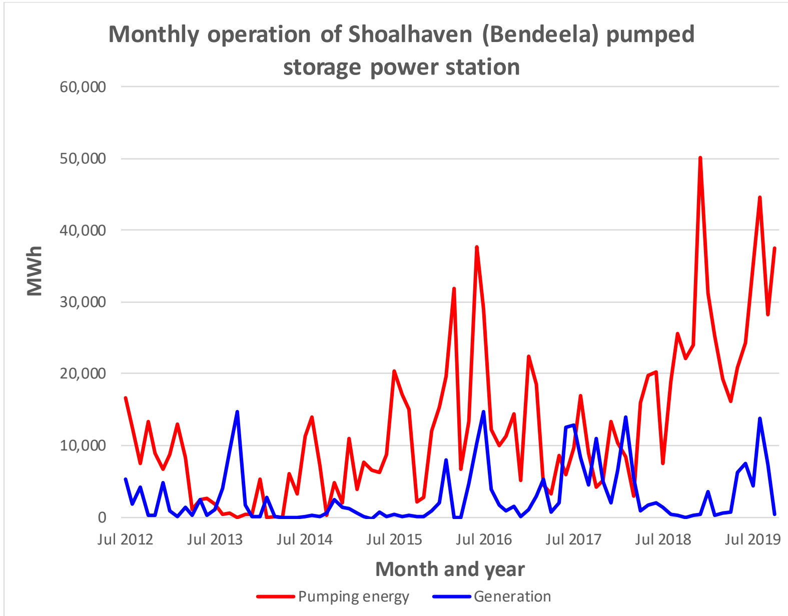
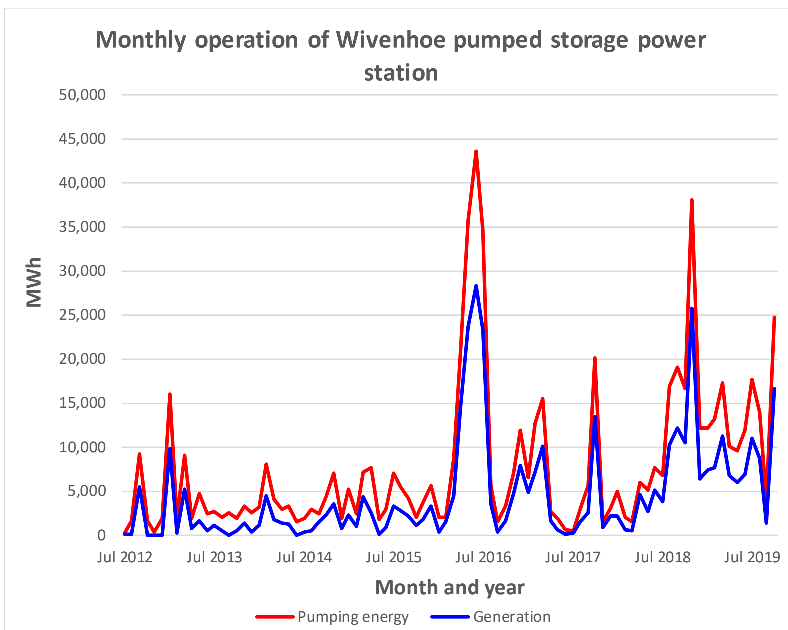


Figure 12

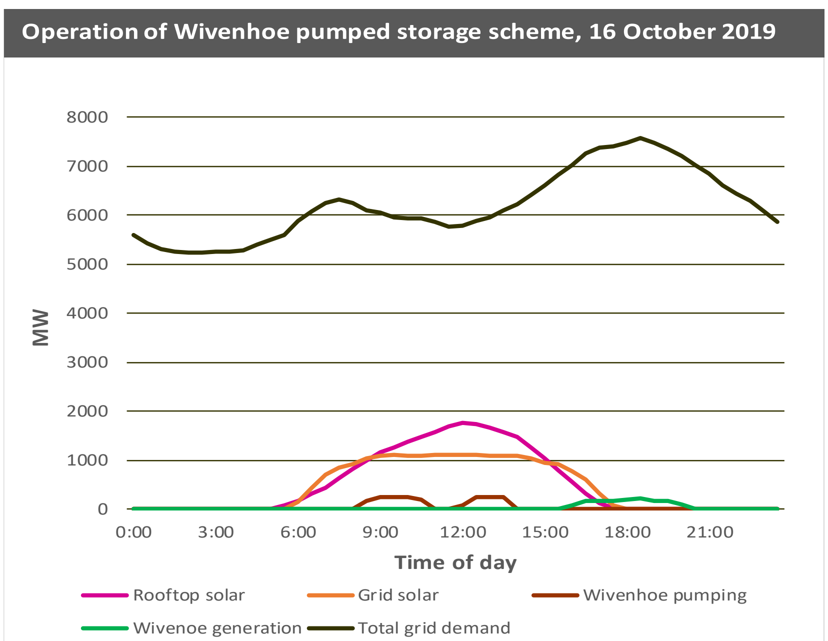


At Shoalhaven, which is owned by Origin Energy, one of the big three gen-tailers, the excess of pumping over generation has arisen because of extensive use to supply water to Sydney. Wivenhoe is the only "pure" pumped hydro scheme of the three. Until the end of October Wivenhoe was owned by CS Energy, one of the two large state government owned electricity generation businesses, with a large portfolio of coal fired power stations. Like Talbingo, until very recently Wivenhoe was not often used, presumably because it was more profitable for CS Energy to supply directly from its power stations. Given that the round trip efficiency of

Wivenhoe is only around 65%, not using it to store coal generated electricity is in fact a lower emission choice, though probably often not a lower cost choice for electricity consumers, since it could add competition to the Queensland wholesale market. When it was used, pumping occurred overnight and generation occurred during the evening peak, after solar generation has fallen away.

This mode of operation, though not the frequency of use, began to change, around April this year, as the rapid growth of solar generation has seen Queensland spot prices often reach their daily minimum in the middle of the day, rather than the traditional slot of the middle of the night, particularly during the spring and summer months. For example, Figure 13 graphs the operation of Wivenhoe on Wednesday 16 October 2019. The pumps used about 930 MWh in the middle of the day, when solar generation was at its peak, and the power station supplied about 710 MWh over four hours in the late afternoon and early evening. The balance of pumping and generation on this particular day suggests a small excess of water volume discharged through the generators over water volume pumped. Over the whole day, total supply from grid and rooftop solar together was over 22,000 MWh, so only a small proportion was time shifted by Wivenhoe. However, this is sufficient to demonstrate the valuable contribution which pumped storage can make to the efficient overall operation of the electricity supply system.

Figure 13



On 1 November ownership of Wivenhoe was transferred from CS Energy to the new CleanCo, the state government owned business established to take an active role in the sustainable transition of electricity supply in Queensland. It is expected, given the increasingly common occurrence of negative prices during the middle of the day in the Queensland wholesale market, as well as the new ownership, that from now on Wivenhoe will be used much more frequently, and will be storing solar rather than coal generated electricity.

Origin has been operating the Shoalhaven scheme in a similar way to Wivenhoe for most of the past two to three years, though this is obscured in Figure 9 by the effect of short periods of continuous pumping transferring water to Sydney. The company is currently completing a detailed feasibility study, supported by ARENA, to build a new underground generator, which will almost double the scheme's generation capacity. Energy storage capacity will be unchanged.

The operating options possible for Shoalhaven and, even more, Wivenhoe, are constrained by the limited capacity of their respective upper level reservoirs. Neither scheme would be able to store energy in quantities to make a material contribution to balancing supply with demand over more prolonged periods than a few hours, such as will be required during periods of prolonged cloudy or windless weather.

By contrast, Snowy Hydro has mainly been using Talbingo by pumping on some days and generating on others. It has much larger storage capacity in Talbingo Dam, and also much larger generating capacity at T3 power station, making it better able to meet longer term requirements. During the past two summers it did this, as seen in Figure 8, by partly holding back water during spring to maximise the volume available should large quantities of generation be required during extreme peak periods. During the week from 6 February 2017, T3 power station played a crucial role by generating at its near maximum capacity of around 1,700 MW for more than three hours. This meant that it effectively supplied all the electricity it was able to do, starting with Talbingo Dam at full supply level. Without this contribution, many New South Wales electricity consumers would have experienced load shedding on Friday 10 February 2017.

The overall operation of Snowy Hydro, as a business, is particularly complex. It is a retailer, with the fourth largest market shares in both New South Wales and Victoria. It is a generator with a dominant role in meeting peak demand in the NEM and, contractually, providing capacity contracts to other retailers and large consumers. Its hydro generation options are constrained by legal obligations to deliver water into the Murray and Murrumbidgee Rivers at specified times in specified volumes. It is seeking to build a very large new pumped storage scheme, in the form of Snowy 2.0, with roughly ten times the energy storage capacity of Talbingo. If it proceeds, Snowy 2.0 will be Australia's largest single investment in electricity supply infrastructure for many years. There are, however, reasons to ask whether it will offer the best return on investment of all the possible options for moving forward at this stage of Australia's electricity system transition, as it is currently expected to progress.

The owners of most of the currently operating coal fired power stations plan to keep them in operation over the next 10 to 15 years, during which time they should be well capable of supplying demand for electricity during extended periods of low wind and solar generation. At this time, a number of smaller pumped hydro schemes, designed to operate on a daily cycle and located closer to major centres of demand and/or renewable generation, may well provide a more effective, lower cost option.

A further drawback of Snowy 2.0 is that it will require an additional investment of several billion dollars in new transmission capacity, lining the scheme to the New South Wales and Victorian grid. Snowy Hydro has argued that this additional interconnector capacity is needed anyway, so should not be seen as part of the Snowy 2.0 investment. While there is no argument with the need for new capacity, AEMO, and many other parties, have concluded that a much higher priority is to increase capacity much further west, where it would also link with the proposed new Riverlink interconnector between New South Wales and Victoria. This project is strongly supported by the state governments, as well as AEMO, and is likely to be completed well before Snowy 2.0 could be operational.

Snowy Hydro is now fully owned by the Commonwealth government. It will be very interesting to see how Snowy Hydro uses Talbingo over the next few years, as it seeks to advance Snowy 2.0.

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.