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NATIONAL
ENERGY
EMISSIONS
AUDIT

National Energy Emissions Audit
Electricity Update

November 2018

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

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Key points

- ***Renewable generation reaches a new record level (again)***

In each of the past five months total annual renewable generation in the National Energy Market (NEM) has reached a new record level, in terms of both total generation and share of NEM generation. In the year to October, grid connected renewables supplied 16.5% of total electricity, of which wind and solar supplied 8.2% and hydro 8.3%. If rooftop solar is also included, the renewable share becomes 19.9%. In Tasmania, the corresponding total renewable share of generation was 93.4%, in South Australia it was 50.2%, in Victoria 19.5%, in New South Wales 12.5%, and in Queensland 7.0%.

- ***Four more new solar farms started supplying the NEM in October***

Four more new solar farms, one each in Queensland, New South Wales, Victoria, and South Australia, started supplying into the NEM grid during October. This is in addition to the four in September. The total installed capacity of solar farms suppling the NEM reached nearly 2.3 GW at the end of October, up from 270 MW just a year ago.

- ***South Australia could go gasless after NEM upgrades***

During 2018, gas generation has been falling steadily in all five NEM states, driven mainly by the high cost of gas and competition from renewables. Based on AEMO modelling, all gas generators in South Australia could be shut down once a new interconnector between South Australia and New South Wales is completed (which the federal opposition would end up funding as a major part of their proposed $5billion Energy Security upgrades).

- ***The Ichthys gas field is unleashed in Darwin with no constraint on greenhouse gas emissions***

The Ichthys gas field began exporting in October and its two main gas reservoirs, one of which contains 8.5% CO_2 in raw gas and the other 17.5% CO_2, are of much higher concentrations of CO_2 than in any other field supplying LNG projects in Australia, except Gorgon which is supposed to be sequestered. The project EIS estimated annual emissions to be 7 Mt CO_2-e, adding about 1.3% to Australia's current total annual emissions.

- ***In September, for the first time in nearly ten years, Snowy Hydro started using its pumped storage on a regular basis***

The first week of September saw a dramatic change in the way Snowy Hydro, now 100% owned by the Commonwealth government, uses its large pumped storage facility at Talbingo. For the first time in ten years, it is now pumping almost every day. Pumping occurs whenever spot prices in New South Wales are at low levels, which includes both the customary time of around 4 am, but also in the middle of the day.

+ ***No change since last month in annual grid electricity demand and total emissions in the NEM***

Over recent months, no change in total electricity demand has meant slight falls in emissions, as growing renewable generation displaced coal generation. In the year to October, however, hydro generation was slightly down, gas generation continued down, but coal generation increased slightly, with the result that emissions stayed constant.

Introduction

Welcome to the November 2018 issue of the *NEEA Electricity Update*, with data updated to the end of October 2018. 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). From time to time it will also include information and commentary on other fossil fuel related emissions, including emissions from consumption of petroleum products and natural gas. This will replace the quarterly *National Energy Emissions Audit Report*, which will no longer be published on a regular quarterly basis. This change will facilitate the reporting of important new data about Australia's energy combustion emissions, as and when such data become available.

Generation, demand and emissions trends

Demand for electricity

During October, as was also the case in September, there was effectively no change in total electricity supplied through the NEM grid (Figures 1 and 2). Total consumption of grid electricity increased slightly in New South Wales and also in South Australia, while it decreased slightly in Queensland, Victoria and Tasmania, and also in Western Australia.

Figure 1

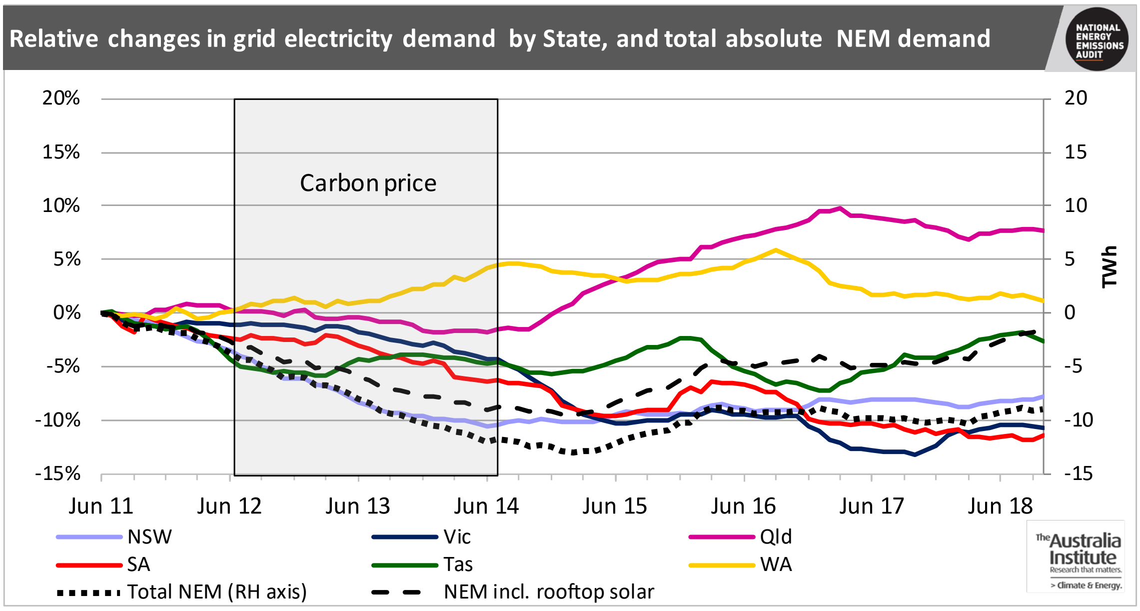
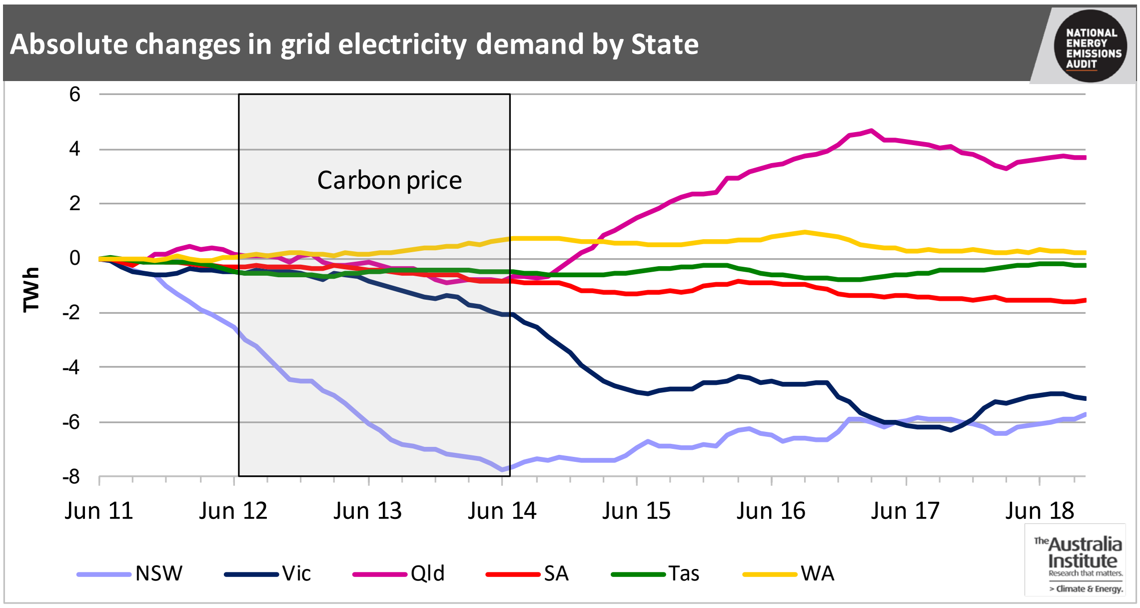


Figure 2



Total annual grid consumption at the end of October was almost exactly the same, at 185 TWh, as at the end of February 2016, with only very small increases and decreases occurring over the intervening period.

Generation and emissions

Figure 3 shows, as would be expected, that total grid generation was almost unchanged in October. It also shows that there was no change in either emissions or emissions intensity of grid generation.

Figure 3

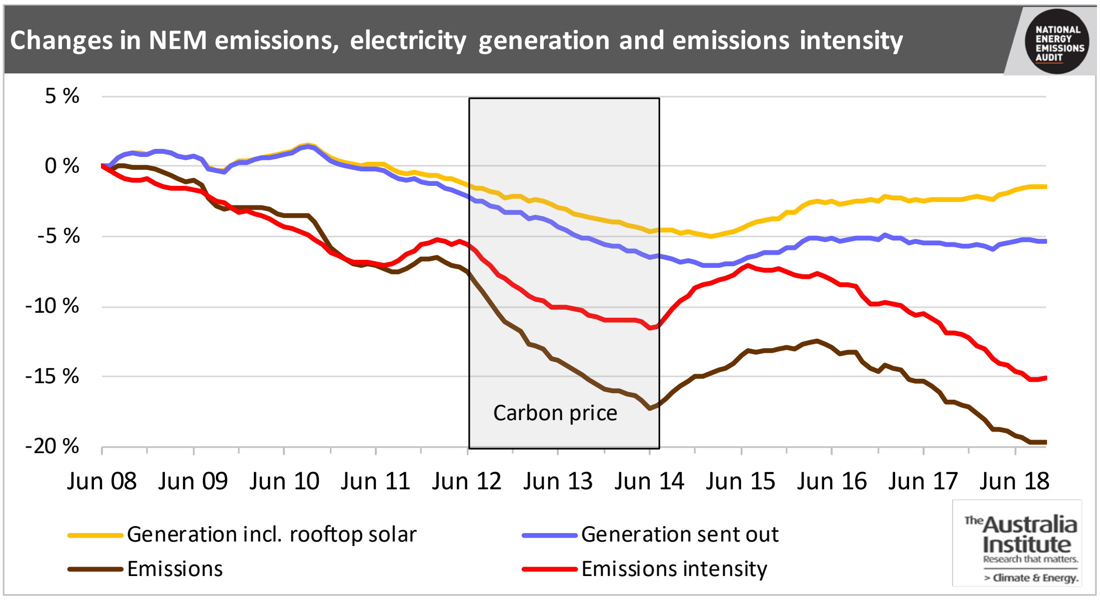


Figure 4

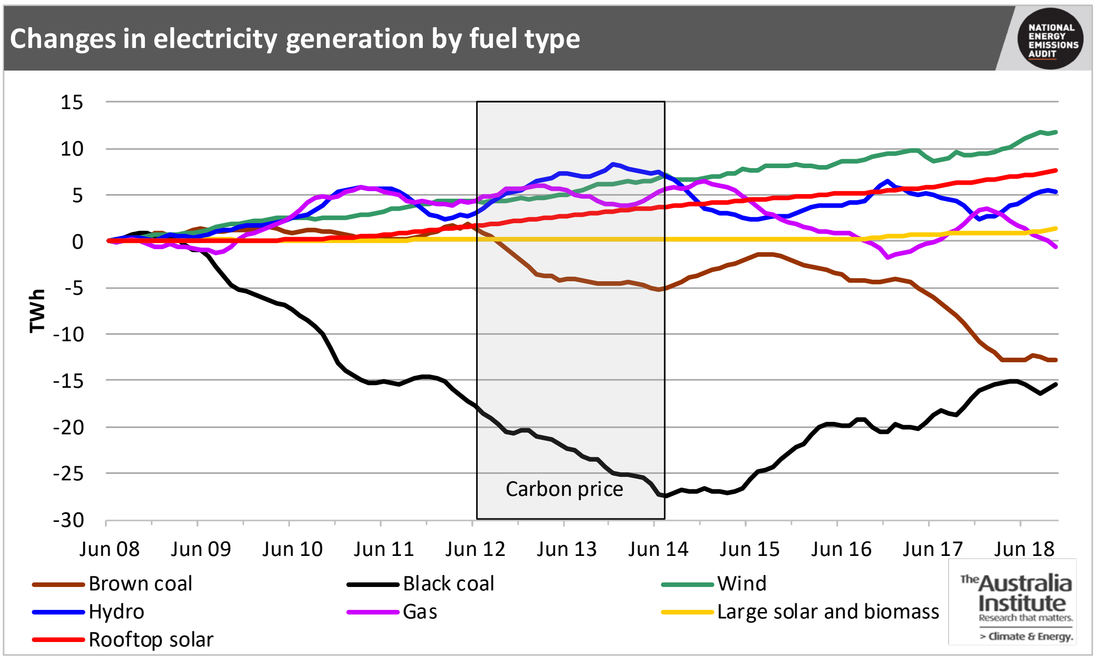
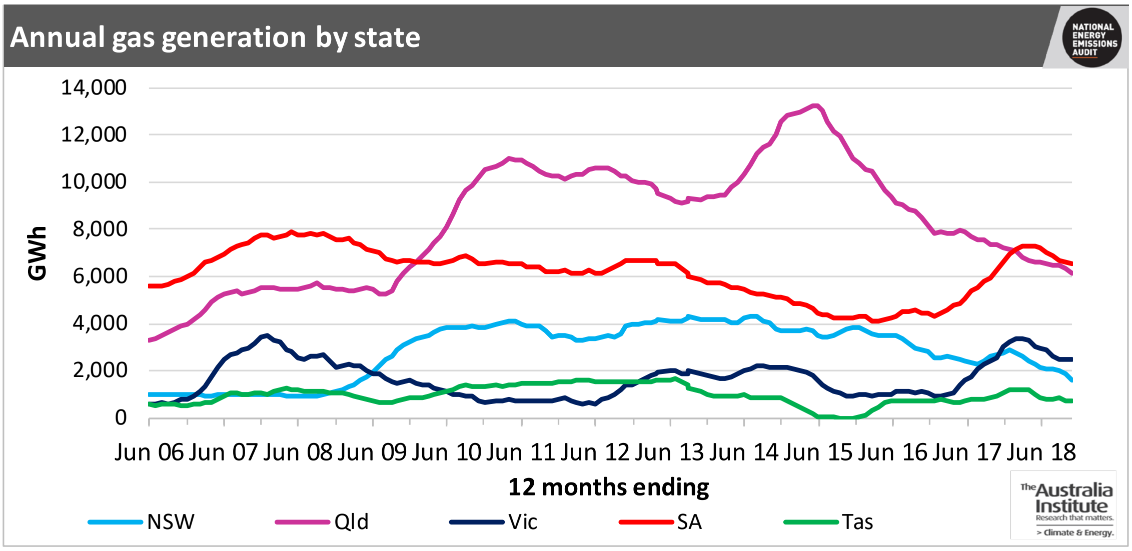


Figure 4 shows that the lack of progress in reducing emissions was caused by a continuing fall in gas generation, which was made up by increased black coal generation. There was no significant change in either hydro or wind generation. More detail on changes in gas generation is provided in Figure 5, covering 12 years from 2006 until now. It can be seen that, during 2018, gas generation has been falling steadily in all five NEM states, driven mainly by the high cost of gas and competition from rapidly growing wind and solar generation. The uniformity of the decline across the whole NEM is quite striking.

Figure 5



Other notable features of the history since 2006 include the following.

- In Queensland, rapid growth in gas generation from 2004 on was driven by the mandatory minimum gas generation share policy of the Beattie Labor government. A further short-lived boost to gas generation was provided by the availability, during 2014-15, of so-called ramp gas, meaning as being produced from coal seam gas fields in preparation for the commissioning of the three LNG plants, and therefore sold at low prices because the plants had not been commissioned and so were unable to use the gas.
- In New South Wales, three new gas generators were commissioned during 2008-09, including Tallawarra (combined cycle) and Uranquinty and Colongra (both open cycle). Colongra has operated at average capacity factors of less than 50% in each of the last four years.
- In Victoria there are no combined cycle generators and all plants except Mortlake (commissioned late 2011) are at least twelve years old. There was a sharp but short-lived increase in gas generation in 2017, following the Hazelwood closure.
- In South Australia, gas generators have been the largest source of supply for many decades. From 2008 to 2015 gas generation was gradually displaced by wind. There was a strong increase in gas generation after the closure of the Northern coal power station, followed by the Hazelwood closure. Following the system black event in September 2016, AEMO adopted a more interventionist approach to managing generator dispatch in South Australia, by requiring minimum combinations of gas generation to be operating at all

times. Over the intervening months, these minimum requirements have been somewhat relaxed, contributing to the decline of the total annual volume of gas generation in the state.

- Interestingly, as pointed out in a special NEEA report published in July, AEMO's Integrated System Plan identifies that all gas generators in South Australia could be shut down once a new interconnector between South Australia and New South Wales is completed. AEMO has identified building this new transmission line as a high priority, which would greatly enhance system security in South Australia by providing two high capacity AC links to the rest of the NEM, one via Victoria and one via New South Wales.

As a final observation it is worth noting that, while wholesale gas prices remain high, combined cycle gas generation is uncompetitive relative to most coal generators. A financial constraint on emissions from electricity generation would level the competition between gas and the much more emissions intensive coal. In the absence of any financial penalty for greenhouse gas emissions, renewable generation will probably to continue displace gas generation, rather than coal, particularly in Queensland. It follows that emissions reductions will be less than they would be if renewables displaced coal generation.

New renewable generation connections

Figures 6 shows grid connected capacity of wind and solar generation at the end of each month. As noted in last month's report, four new solar farms started supplying electricity to the grid during September. A further four started during October; these are: White Rock, 20 MW in New South Wales, Daydream, 180 MW .in Queensland, Bungala Two, 140 MW in South Australia, and Karadoc South, 112 MW in Victoria. The eight new projects over the past two months account for the upsurge in solar capacity seen in Figures 6 and 7. By contrast, there were no new windfarms supplying the grid during September and October, but there are a number currently under construction.

Figure 6

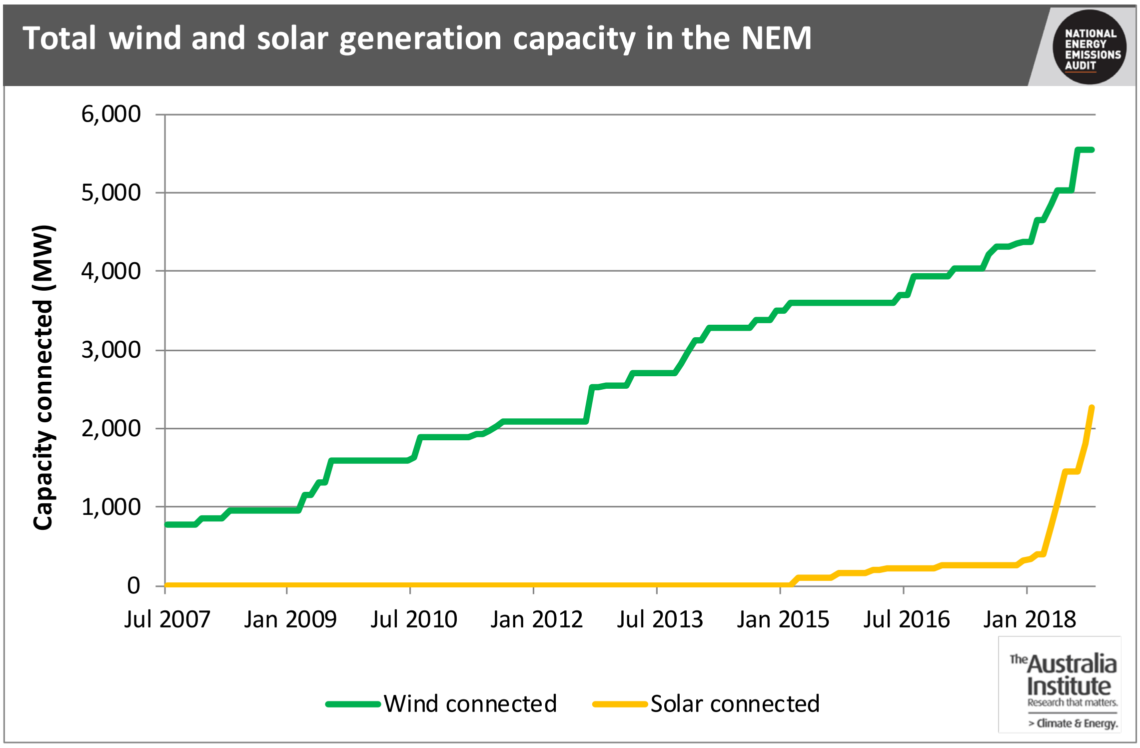


Table 1 below shows shares of wind and solar generating capacity by state. There has been no change since last month for wind, but the four new projects listed above have had the effect of slightly reducing the shares of capacity in both Queensland and New South Wales, and increasing capacity shares in Victoria and South Australia.

Figure 7

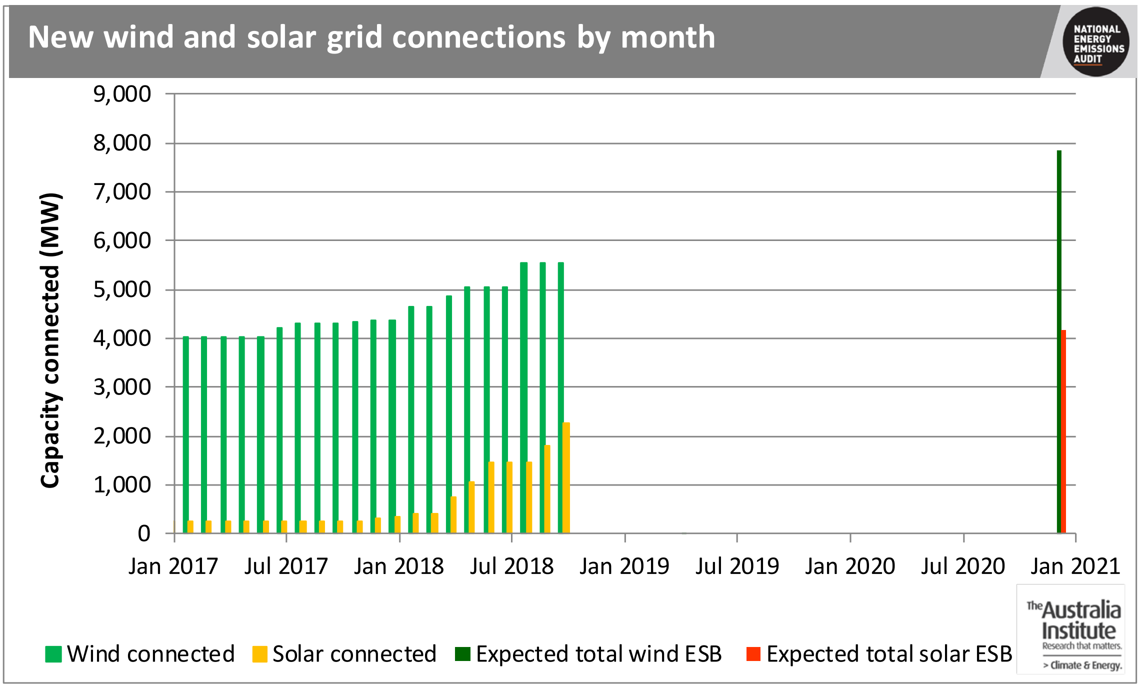


Table 1: Share of NEM wind and solar capacity by state – October 2018

	Share of NEM wind capacity	Share of NEM solar capacity
New South Wales (incl. ACT)	27%	25%
Queensland	3%	51%
Victoria	30%	12%
South Australia	34%	12%
Tasmania	6%	0%

An examination of pumped hydro operation

Australia has three long established pumped hydro schemes. The oldest, and largest, is Talbingo, also called T3, which was commissioned in 1974 as the last component of the Snowy Mountains Scheme. It has a relatively large upper storage, Talbingo Dam, on the Tumut River, with generation capacity of 1,500 MW and pumping capacity of 600 MW. In 1977 the Shoalhaven Scheme, also in New South Wales, was commissioned. It has a large lower storage, in the form of Tallowa Dam on the Shoalhaven River, and total generating and pumping capacity of 240 MW at two power stations, Kangaroo Valley and Bendeela. Finally, Wivenhoe in Queensland also has a large lower storage, in the form of Wivenhoe Dam on the Brisbane River. It was commissioned in 1984; it has a total registered generating capacity of 500 MW and pumping capacity of 480 MW.

Shoalhaven was built by the Energy Commission of New South Wales, and Wivenhoe was built by the Queensland Electricity Commission. In both cases, as well as in the case of Talbingo, the rationale for the schemes was two-fold. Firstly, they would supply additional capacity to supply morning and evening weekday peaks in electricity demand. Note that they were built some years before the wide availability and adoption of open cycle gas turbine generators. Secondly, the pumps would provide additional base load so that each Commission’s inflexible coal fired power stations could operate more efficiently because they would not need to vary output up and down so much. The schemes were operated by the respective Commissions as an integral part of their respective fleets of mainly coal fired power stations. (Snowy worked closely with the New South Wales Commission.)

The unbundling of generation assets, followed, in the case of New South Wales, by their privatisation, has fundamentally changed the operating economics of these schemes. Shoalhaven is now owned by Origin Energy, one of the three big vertically integrated “gentailers”, which also owns Eraring, Australia’s largest coal fired power station, as well as gas generators in Queensland, New South Wales, Victoria, and South Australia. Wivenhoe is owned by CS Energy, one of the two big state government owned, predominantly coal fired generators in Queensland. Talbingo is owned by Snowy Hydro, which, in addition to all the other hydro power stations in the Snowy, has gas and oil fuelled open cycle gas turbine peaking generators in New South Wales, Victoria and South Australia. Snowy Hydro is now fully owned by the Commonwealth government.

Figure 8

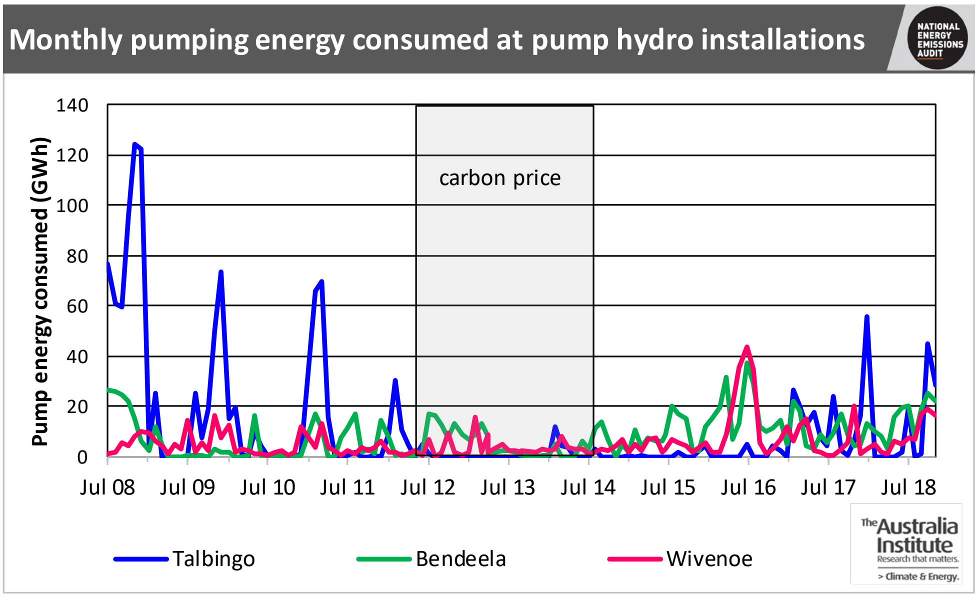
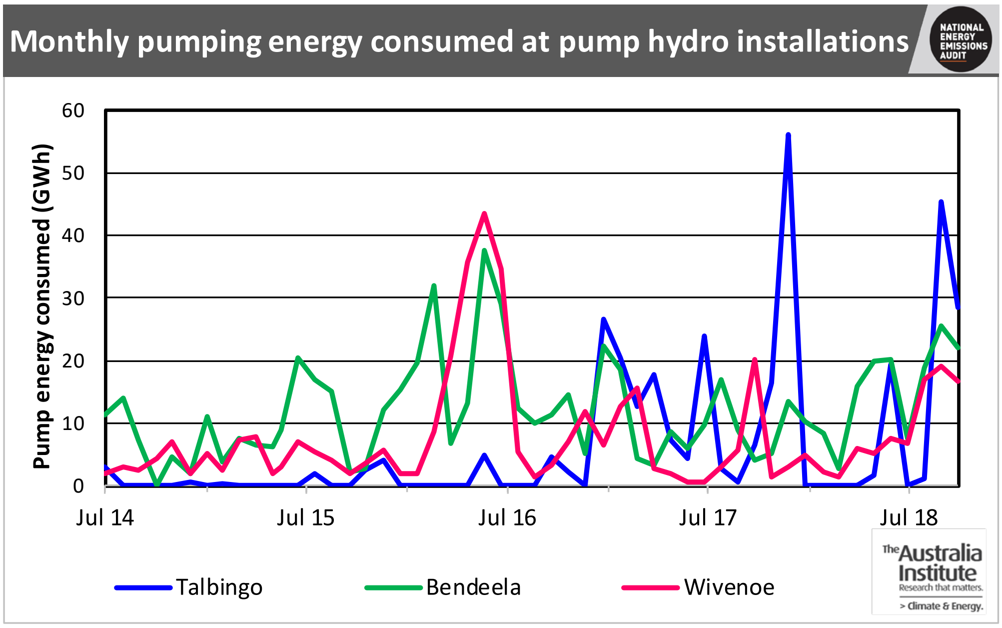


Figure 8 shows utilisation, measured as monthly total pumping load, of the three schemes over the past ten years. Talbingo has mainly been used in the summer months, to provide a stored energy reserve to call on if needed to meet demand on extreme peak demand days. Talbingo came to the rescue of New South Wales electricity consumers on the peak day in February 2017. Without its ability to run at its maximum capacity of over 1,700 MW for several hours, it is likely that a great many electricity consumers would have suffered blackouts. However, it can be seen that, from 2012 to 2016, Talbingo was not used for even this purpose. A similar, though less extreme pattern is seen for Wivenhoe, whereas use of Shoalhaven has been much more consistent over the whole period. Recent years are shown in more detail in Figure 9.

Figure 9



Over the past year Origin has been using Shoalhaven in both pumping and generation modes on most days of the year. Since the end of a two week shut down in March, there have been only five days on which neither pumping nor generation occurred. Over the whole year to October 2018 the pumps were used on 78% of days. By contrast, over the same period, Wivenhoe pumps were used on 43% of days and Talbingo pumps were used on only 25% of days. In previous years, Talbingo pumps received even less usage. It is reasonable to suppose that, as a large gentailer, Origin was able to internally arbitrage its operation of Shoalhaven. By contrast, one can speculate that CS Energy and Snowy Hydro would see their pumped hydro schemes as competing directly against, and delivering smaller net margins than, their other generators.

Most interestingly, however, Wivenhoe and, most particularly, Talbingo have been used far more frequently over the past two months, as can be seen in Figure 9. It is not immediately obvious why this might be so, as there are several quite plausible possible explanations. A cynic might suggest that, either the Board and management of Snowy Hydro, very keen to win approval for their huge new Snowy 2,0 plans, are keen to demonstrate the services pumped hydro can provide to electricity consumers, or, alternatively, that their sole shareholder, the Commonwealth government, has directed them to make more use of Talbingo for similar reasons.

However, no cynicism is needed to identify other explanations which are equally if not more plausible. One is that higher gas prices have made pumped hydro more competitive with open cycle gas turbine generators as marginal suppliers of peak early evening demand. Another is that the steady growth of solar generation in New South Wales and Queensland has lowered wholesale prices in the middle of the day enough to deliver attractive daily arbitrage margins between midday and early evening on most sunny days.

More analysis will be required to further understand these changes in the operation of pumped hydro installations. It is interesting, however, that a quick analysis of the operation of Talbingo between 1 September and 31 October suggests that the gross margin between the spot market cost of energy purchased for pumping and the spot revenue from electricity generated was of the order of $3.2 million, equal to about 70% of the cost of pumping energy. Of course this figure greatly exaggerates the profitability of the operation, as it makes no allowance for transmission costs, operational costs or other overheads. Not does it allow for the fact that not all the water passing through the turbines at T3 power station was previously pumped up into Talbingo Dam. Some of the water comes from the "normal" operation of the Snowy Scheme, having previously been released from Lake Eucumbene and passed through both T1 and T2 power stations before flowing into Talbingo Dam.

Nevertheless, it is clear that existing pumped hydro schemes can make a very valuable contribution to "firming" output from current solar generation, at least in New South Wales. At present, the Talbingo pump load is greater than the combined peak capacity of all grid scale solar farms in New South Wales. Moreover, maximum active storage in Lake Talbingo is sufficient to supply all electricity generated from these solar farms for several days in succession. This demonstrates the practical value of pumped hydro storage as a complement to solar and wind generation.

This does not, however, mean that Snowy 2.0 is the best option for additional pumped hydro capacity, given the number of alternative possible sites right across the area covered by the NEM. The very large size and cost of the scheme itself, plus the very large additional investment needed for major upgrades in transmission connections to both New South Wales and Victoria, mean that it may well be preferable to delay building the scheme until the early 2030s, when substantial coal power station closures are expected to occur.

A quick update on greenhouse gas emissions from LNG production

The previous NEEA Electricity Update included a discussion of trends in other sources of Australia's greenhouse gas emissions, including fugitive emissions from LNG operations. Mention was made of Ichthys project in Darwin, operated by the Japanese company Inpex. The project is now fully operational, having shipped its first LNG cargo in October and been officially opened by the Japanese Prime Minister in early November. The Ichthys gas field consists of two main gas reservoirs, one of which contains 8.5% CO_2 in raw gas and the other 17.5% CO_2. These are much higher concentrations of CO_2 than in any other field supplying LNG projects in Australia, except Gorgon. The Environmental Impact Statement (EIS) for the project estimated that total annual emissions from the project would be about 7 Mt CO_2-e, comprising both combustion emissions from the gas consumed to power the liquefaction process, and CO_2 stripped from the raw gas prior to liquefaction, and vented to the atmosphere. The 7 Mt will increase Australia's current annual greenhouse gas emissions by about 1.3%.

In addition, in September Woodside Petroleum announced that it was proposing to develop the Browse gas resources by means of a subsea pipeline to the North West Shelf LNG facilities. In October the company referred the proposal to the state and Commonwealth environmental protection authorities. The three gasfields which would supply this project contain similar CO_2 content as the Ichthys fields. To date, Woodside has said nothing about CO_2 sequestration in association with the Browse development. It is interesting, in this context, that the Chief Executive of Woodside Petroleum should have recently made a strong public statement in support of placing a price on emissions.

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.