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NATIONAL ENERGY EMISSIONS AUDIT

National Energy Emissions Audit
Electricity Update

February 2018

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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Introduction

Welcome to the February 2018 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's issue covers data to the end of January 2018.

Each issue of *Electricity Update* contains a more detailed discussion of one or two particular issues relating to the electricity system.

In this issue, we provide some general background information on how the mix of generation types in each of the five state regions of the NEM has changed over the past ten years, highlighting the both the similarities and differences between states. A graph illustrating how the Hornsdale "big battery", in South Australia, is being used to "time shift" wind generation from periods of low demand and low price to later times of high demand and price is also presented.

Key points

+ ***Electricity generation emissions in the NEM fall to their lowest level since 2004.***

In the year to January 2018, emissions from electricity generators supplying the NEM fell to 152.8 Mt CO2-e, as calculated by the NEEA model, the lowest level since 2004 – a success of the Large Renewable Energy Target policy.

+ ***NEM electricity consumption keeps going down***

Annual demand continues to gradually decline in the NEM as a whole, and in New South Wales and Queensland, the two states with the largest consumption in the NEM, accounting together for almost two thirds of total NEM consumption. Consumption in South Australia and Western Australia remains virtually constant, while it is increasing in Victoria and Tasmania.

+ ***New South Wales and Queensland lag behind other states in the transition away from fossil fuel generation***

Tracking each state's transition away from fossil fuels show that coal and gas generators supply 95% of all electricity generated in Queensland and 90% in New South Wales. Corresponding figures for Victoria are 84% and for South Australia 55%. In Tasmania, hydro, wind and rooftop solar supply 90% of all electricity generated.

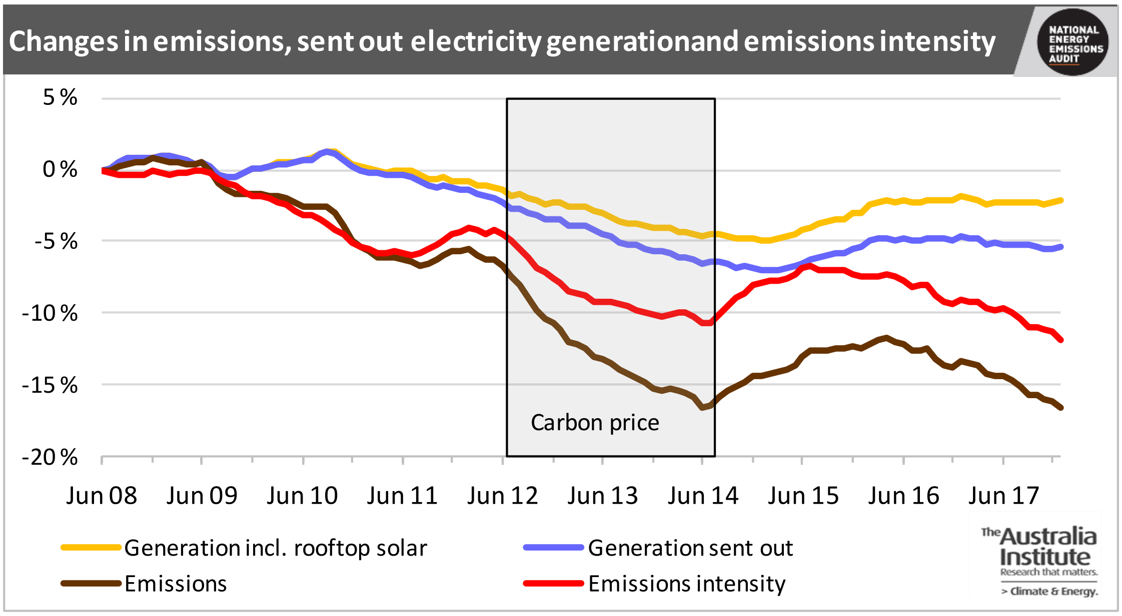
+ ***Performance of the Hornsdale Power Reserve "big battery' in South Australia***

During January, the Hornsdale Power Reserve "big battery" was used daily to charge overnight, when wind generation is often abundant and cheap, and discharge in the late afternoon, when total demand and spot market prices usually reach peak levels, demonstrating the very valuable role that energy storage can play in the operation of an electricity supply system with high levels of renewable generation.

Generation, demand and emissions trends

The National Electricity Market (NEM) continued the trend which has now lasted for almost two years, with total 'generation sent out' to the grid almost constant and both emissions and emissions intensity going down (see Figure 1 below).

Figure 1



Total demand for electricity In the NEM was very slightly up in January, to the highest level since the year to March 2017, while there was a very small decrease in WA. The overall consequence for the NEM is that annual consumption – termed operational demand by AEMO – has been almost constant for nearly two years. Electricity consumption, expressed either per head of population or per real dollar of GDP, has been falling since March 2016 at a rate of more than 2% per annum, and continues to do so.

During January, total electricity supplied by generators to the NEM (in blue) increased very slightly, but total annual emissions from those generators (in brown) continued to decrease, as shown in Figure 1. Total emissions in the year to January also continued on trend, reaching a level of 152.8 Mt CO_2-e. [1]This the lowest level since 2004, a time when electricity consumption was considerably lower than today, and emissions were expected to continue to grow strongly; it is lower than the lowest level seen since 2004, reached in June 2014, just as the short-lived carbon price ended. The average emissions intensity of grid generation also fell

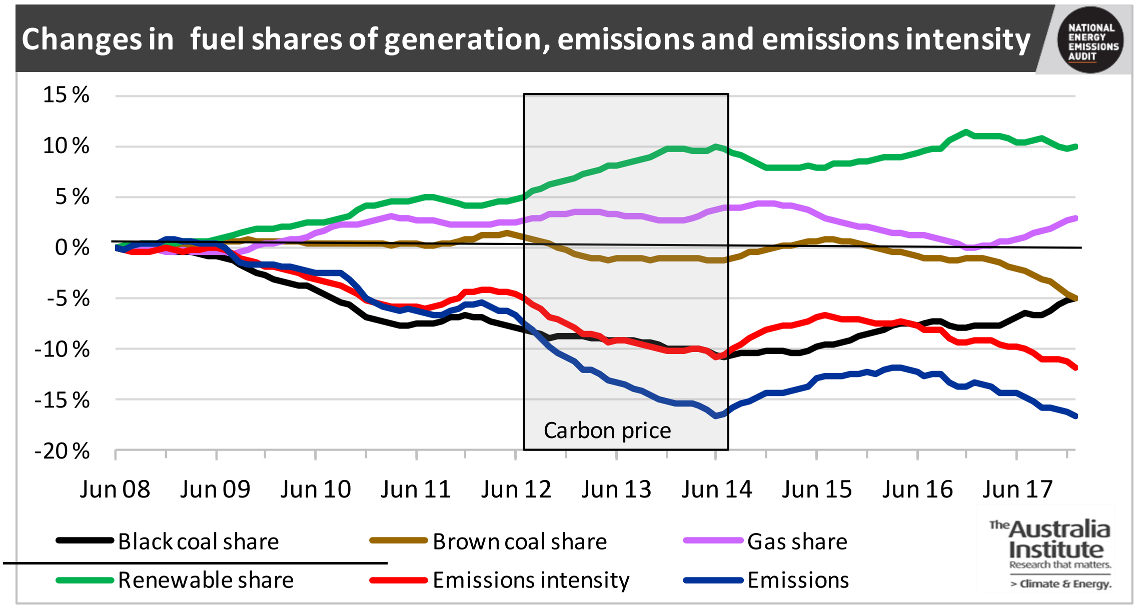
[1] As calculated by the National Energy Emissions Audit model

again in January, to a new record low level of 0.827 t CO_2-e/MWh[2]. Intensity has now been below the 2014 level for five successive months.

As the *National Energy Emissions Audit* and its predecessor publication have regularly pointed out, the low emissions level of 2014 was an artefact of the short life of the carbon price. Snowy Hydro and, especially, Hydro Tasmania, ran storages down to unsustainable levels, correctly anticipating that the opportunity to profit from the cost advantage provided by the carbon price would be shot-lived. This time the emissions reduction is more permanent, driven by the Large Renewable Energy Target (LRET) policy and assisted by the increasing decrepitude of Australia's ageing fleet of coal fired power stations. The success of the LRET in reducing Australia's emissions from electricity generation, its primary goal, should be recognised and celebrated. At the same time, it must be acknowledged that too many policy makers have, until recently, ignored the implications for most other aspects of electricity supply system operation of steadily increasing the share of renewable generation. The problems are by no means insoluble, but measures to solve them must be implemented.

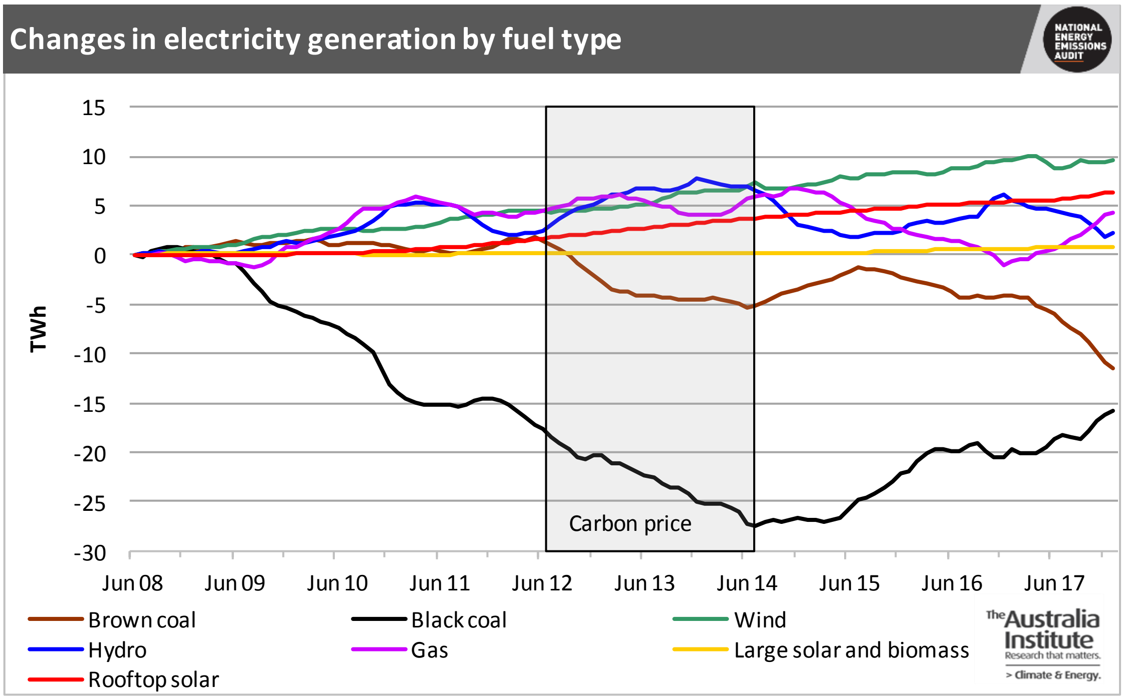
It is now virtually certain that the 33,000 GWh renewable generation target will be achieved. Therefore, in the absence of a completely unexpected surge in electricity consumption, emissions and emissions intensity can be expected to continue their steady fall until 2021. Even so, however, the Australian electricity generation system will remain one of the most coal dependent and emissions intensive amongst major developed countries. Reaching an agreed national post-2021 policy framework for Australia's electricity system is a most urgent task. Any policy must ensure that electricity generation emissions continue to fall, while also ensuring timely and economically efficient investment in the new technologies which are needed to ensure that the reliability of electricity supply, and the security of grid operation, remain at acceptable levels.

Figure 2



[2] See above

Figure 3



The changes in the mix of generation supplying the NEM, which have driven the fall in average emissions intensity, are shown in Figures 2 and 3. In the year to January 2018, annual brown coal generation continued to fall, while black coal generation continued to grow. There was an up-tick in hydro generation supplied to New South Wales and Victoria from the Snowy, and an offsetting slow-down in the growth of gas generation in these two states. Annual wind generation remains below the level it reached in the year to March 2017, reflecting the continuing legacy of the extremely low generation during June 2017 (the worst month for wind generation since the industry started in Australia, as was shown in Figure 10 in the January *NEEA Electricity Update)*.

Figures 4 and 5 show, respectively, absolute and relative changes in demand for electricity supplied from the grid in each of the five state regions of the NEM and in the South West Interconnected system in Western Australia. The trends again show little change since last month. Total NEM annual consumption was almost exactly constant, as it was in South Australia and Western Australia. Consumption fell in Queensland and New South Wales. It increased in Victoria, for reasons which are not obviously related to weather, as average temperatures for December and January as a whole were not very much higher than last summer, when electricity consumption was much lower. Consumption also continued to increase in Tasmania.

Figure 4

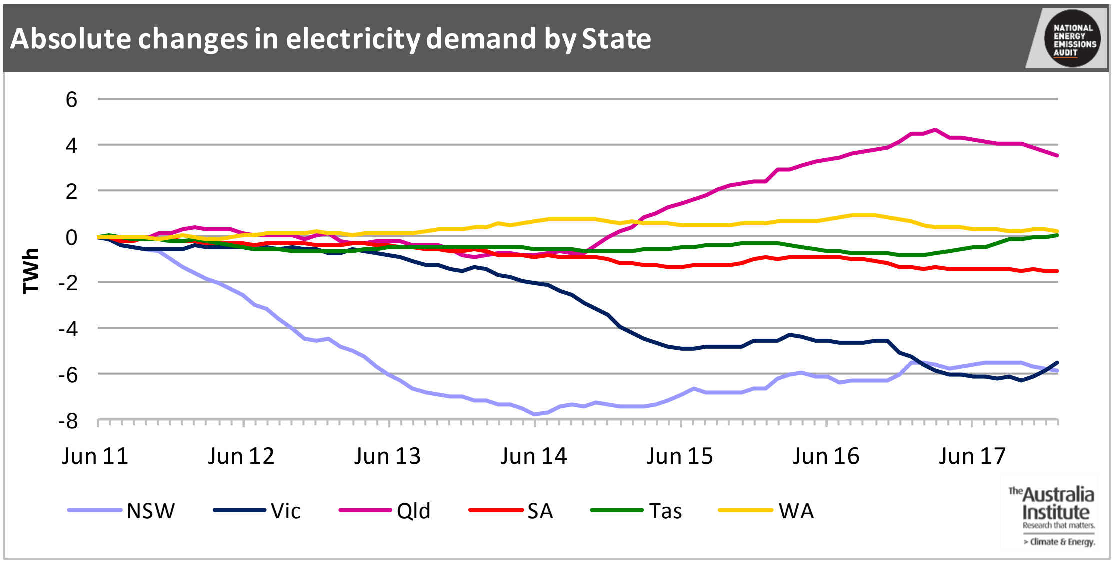
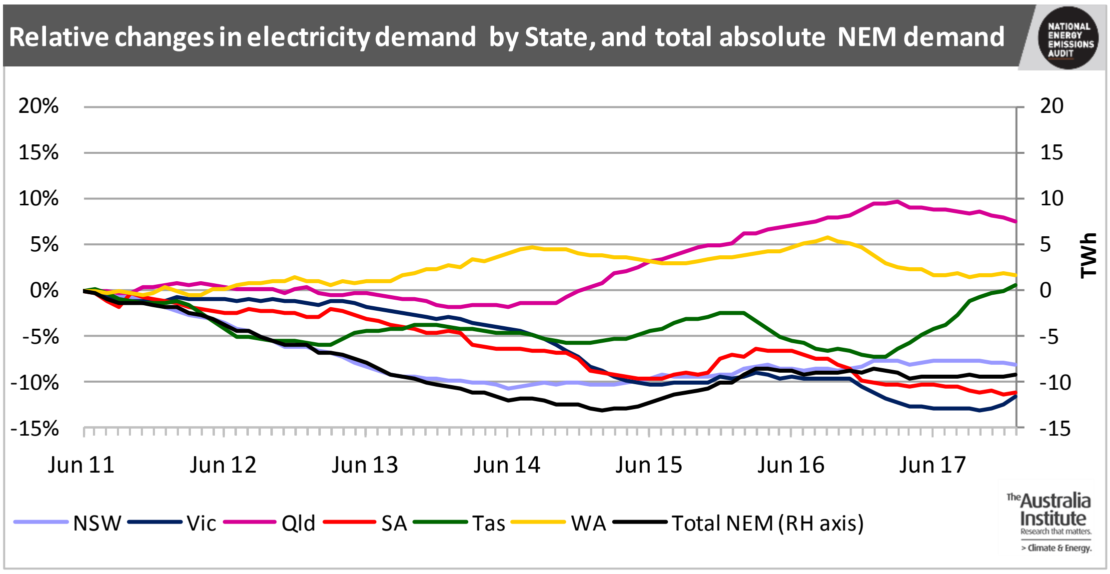


Figure 5



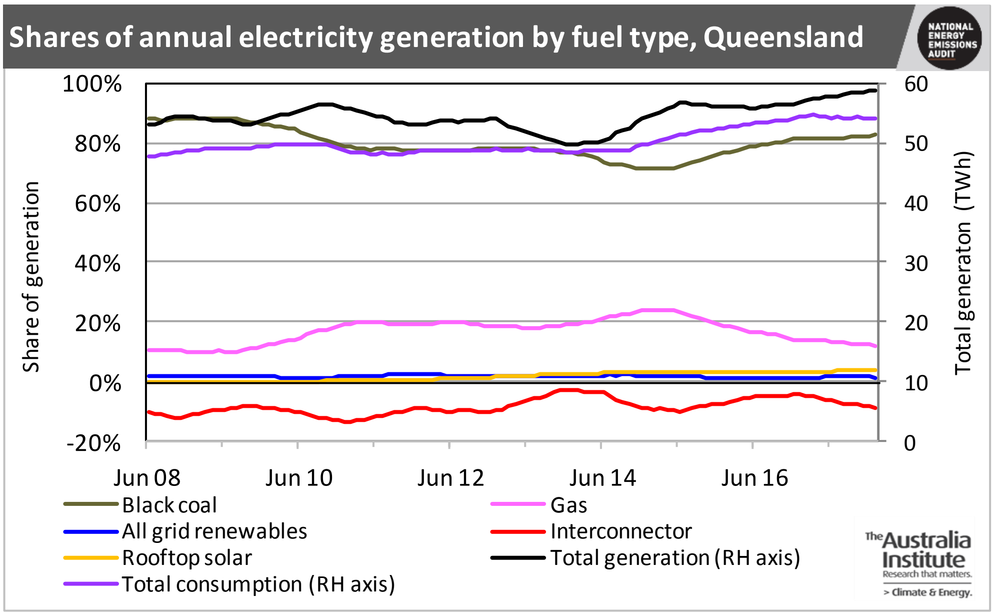
A more detailed state-by-state look at generation

At the present time, a large number of wind and grid -scale solar generation projects are under construction in each of the four mainland NEM states, and many more are expected to start construction in the coming months. This issue of *National Energy Emissions Audit - Electricity Update* provides background to these impending changes to NEM generation, by looking at the generation mix in each of the five NEM states over the past ten years. The presentation moves from Queensland, the state with the lowest share of renewable generation, to Tasmania, the state with the highest renewable share. In recognition of the growing importance of small scale (rooftop) solar generation, estimated generation from this source has added to grid level generation and consumption in each graph.

Queensland (Figure 6) currently has no grid scale wind generation, just one small solar farm, and two small, long established hydro power stations in the far north. As a result it has the highest share of fossil fuel generation, at just under 95% in the year to January 2018. Its large fleet of coal fired power stations are, on average, younger and have access to lower cost coal resources than New South Wales coal generators. In addition, it has a large number of relatively modern gas power stations, mostly built with the assistance provided through the gas generation target policy (13%, later 15% of retail electricity sales) introduced by the Beatty Labor government to support the initial development of coal seam gas production. Figure 6 shows initial growth in the gas share of generation to meet the target, subsequent short lived additional growth between 2013 and 2015, when generators had access to low cost "ramp gas" while LNG plants were being built, and, finally, decline in the face of much higher prices for gas.

Gas generators provide the Queensland system with the load following capability that in New South Wales and Victoria is largely supplied by hydro generators. They also contribute to Queensland's spare capacity which led AEMO to project, in its *2017 Statement of Opportunities,* that low reserve conditions would not occur over the next ten years. Spare, low cost generation capacity has resulted in Queensland consistently exporting a significant share of its electricity generation to New South Wales.

Figure 6



In New South Wales, hydro, wind and solar renewable generators currently account for about 9% of total generation (Figure 7) and fossil fuel generators the remaining 91%, of which only 4% is gas. However, consumption has been consistently higher than generation, by as much as 20%, as net imports of mostly fossil fuel generated electricity from Queensland and Victoria have contributed significantly to total supply. Although still small, the share of wind and solar (both grid scale and rooftop) has been growing steadily, to the point where it is now roughly equal to hydro generation, most of which comes from the Tumut half of the Snowy scheme, which is linked to the New South Wales NEM region.

Figure 7

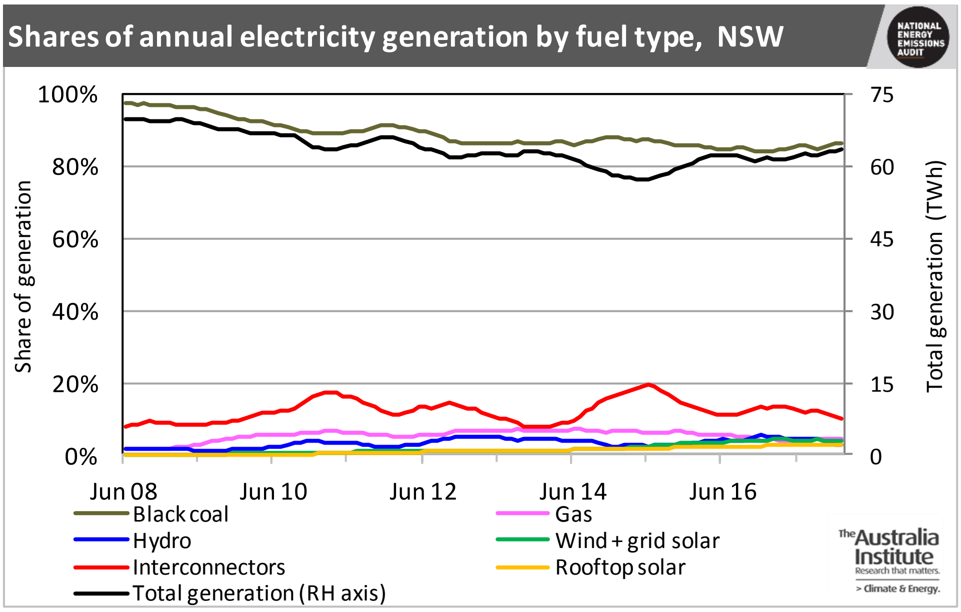
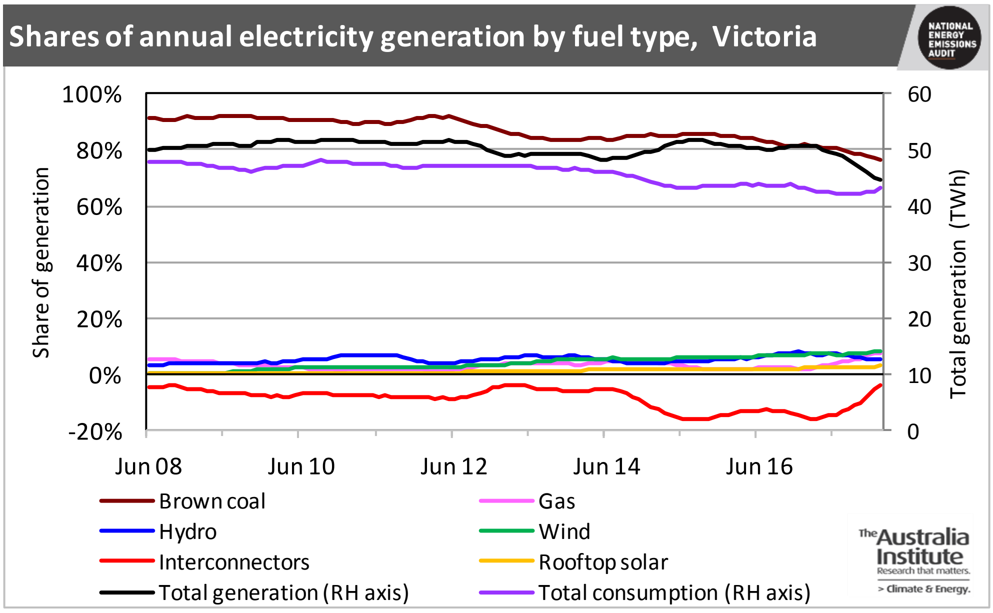


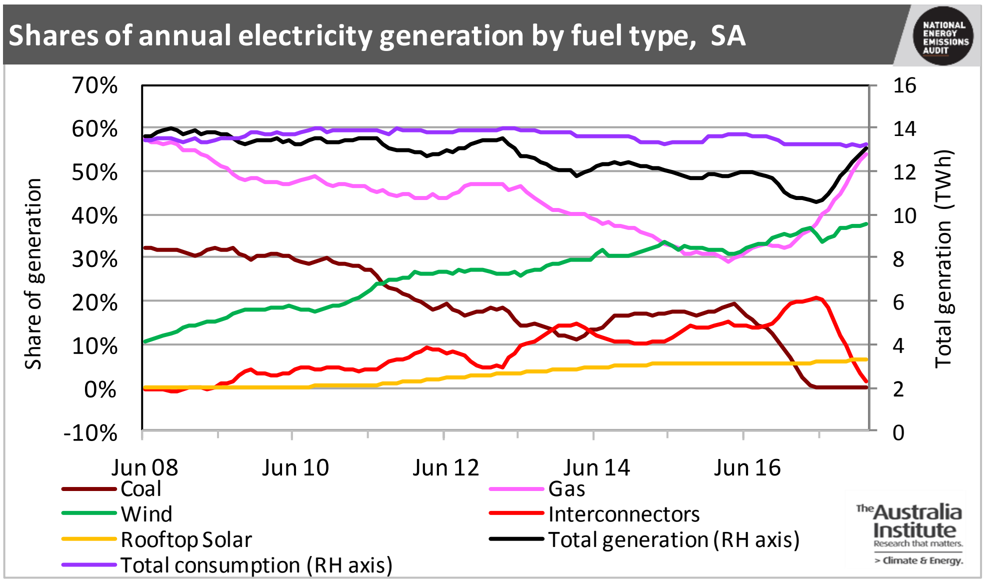
Figure 8



In Victoria (Figure 8), renewables now supply around 16% of total generation, of which variable renewables (wind and solar) account for about two thirds and hydro the remainder. These shares have increased markedly since the decline in total state generation, caused by the closure of Hazelwood power station in March 2017, as clearly seen in the graph. Most of the reduced generation was offset by a large reduction in net exports to all three neighbouring regions – New South Wales, South Australia and Tasmania. It seems likely that when a full year since the Hazelwood closure is reached, at the end of March, electricity generation and consumption will be roughly equal, on average, in Victoria, though this will change again over the following few years, as many new wind and solar generators come on line.

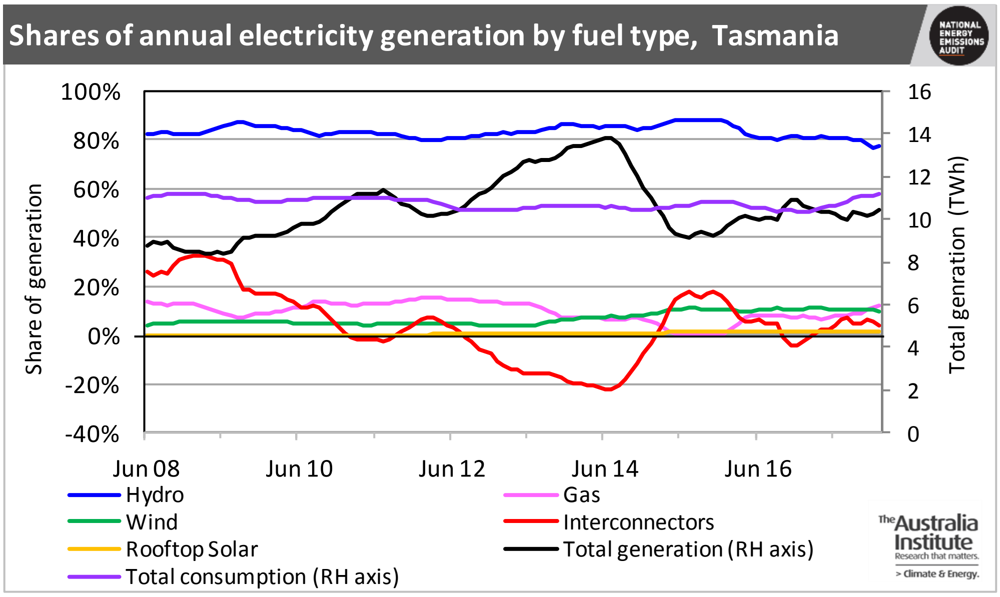
South Australia (Figure 9) is the NEM region with by far the highest share of variable renewable generation, at 45%. Gas supplies the remaining 55% of generation in the state. Net imports through the two interconnectors with Victoria were previously an important contributor to total state consumption, but interconnector flows are now moving steadily towards approximate balance; **during every month from July to December, exports to Victoria exceeded imports from Victoria.** Comparison of the five state graphs presented here makes it very easy to see why South Australia is encountering the challenges of incorporating variable renewable generation into an established electricity supply system so much sooner than other NEM regions. Recent developments show South Australia is becoming a world leader in implementing new technologies to address the integration of intermittent generation into an established electricity supply system. In watching the new storage and other technologies it is important not to ignore the important contribution which interconnector exchanges with Victoria, and also exchanges between Victoria and Tasmania are playing in making best use of the mix of generation technologies across the three states. That explains why there is renewed interest in building a new interconnector between South Australia and either Victoria or New South Wales or, possibly, even Queensland.

Figure 9



Finally, Tasmania (Figure 10) pioneered the construction of an electricity distribution system based on hydro generation in the 1890s (at Launceston) and has been overwhelmingly reliant on hydro generation ever since. In the year to January 2018 hydro accounted for 77% of total generation and wind, together with a small amount of rooftop solar, a further 11%. Gas generation provided the other 12%. The hydro share of generation has been relatively stable, at between 80% and 90% over the past decade, though the total amount of electricity generation has varied considerably. It rose to a very high level during the 2012 to 2014 carbon price period, as Tasmania was able to profit from the large relative reduction in its cost of generation. Hydro generation subsequently dropped sharply, affected by the need to replenish storage levels, followed by drought. Further turbulence was caused by the loss of the Bass Strait cable interconnector between December 2015 and June 2016; this shows up as a small uptick in annual generation for 2016.

Figure 10

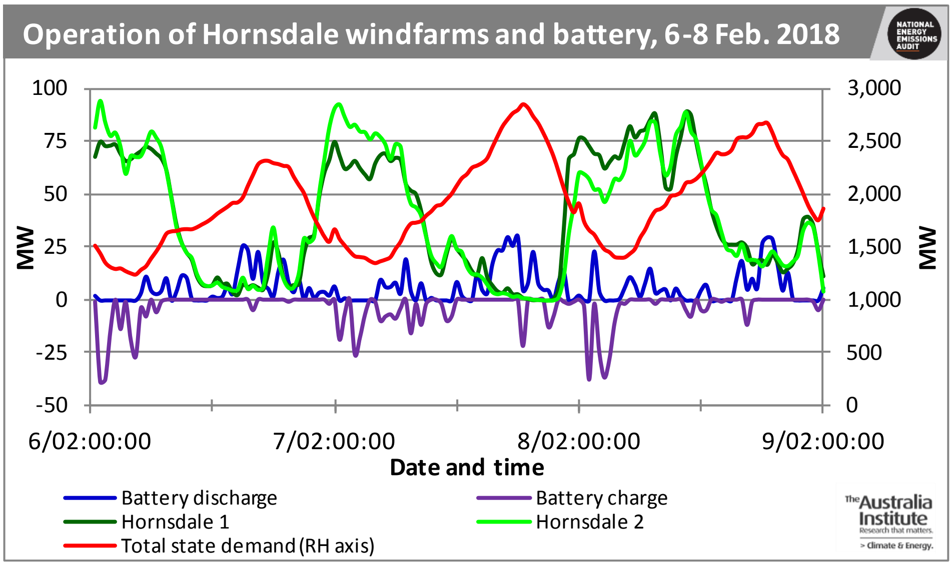


During January, Tasmania has been exporting electricity to Victoria during daylight periods on every day with above average demand, and importing overnight when demand and wholesale prices are lower in Victoria. Weather patterns mean that very high demand, invariably associated with hot weather, often occurs on the same day(s) in Victoria and South Australia. On many such days, energy imported to Victoria from Tasmania allows Victoria in turn to export to South Australia, meaning that Tasmania is, in effect, supplying South Australia in net terms. This is a clear demonstration of how interconnectors between state regions can enhance reliability across the NEM.

Hornsdale battery operation

Very high demand days in summer are often associated with spikes in the wholesale spot price, usually occurring in the afternoon, an hour or two before the system peak and two or three hours after peak output from rooftop solar. In addition, in hot weather there is often significant wind overnight and the early morning, dropping away towards the afternoon. These relationships point to the potential value of storage which is able to move energy a few hours, from the times of peak wind and solar generation to the time of peak system demand. This is precisely what the operators of the Hornsdale "big battery" in South Australia, officially called Hornsdale Power Reserve, have been doing over recent weeks. Figure 11 is an example from three very hot days (maximum temperatures of 36, 41 and 41 degrees C in Adelaide) with high demand for electricity in early February. The graph plots flows of electrical energy at 30 minute intervals, from 30 minutes past midnight on 6 February to midnight on 9 February.

Figure 11



The graph shows a consistent pattern of charging up overnight, when prices are very low (well below $100 per MWh on all three days) and discharging in the late afternoon, when prices are very high ($8,000 per MWh between 4.00 and 4.30 pm local time on 7 February, which is 3.30 to 4.00 pm NEM time, as shown in Figure 11, somewhat lower on the other two days).

There are a couple of important points to bear in mind when interpreting this graph. Firstly, energy flows are capped at 30 MW because only 30 MW of the total battery capacity of 100 MW is committed to energy arbitrage. The remaining 70 MW are held in reserve to provide frequency control services, contributing to the security of the grid. Secondly, since the battery can charge and discharge in a matter of seconds, and frequently does so, the relatively coarse-grained data in Figure 11 under-estimates flows of energy in and out of the battery, though it does accurately represent the maximum power (30 MW).

Sceptics will point out that 30 MW is hardly more than 1% of the peak demand of 2.9 GW on 7 February. This is true, but not particularly relevant. The Hornsdale battery is the first of its kind. Planning for a number of others in South Australia, Victoria and elsewhere is well underway. Since the capacity requirement for frequency control services is limited, it is almost certain that a number of subsequent battery projects will devote a larger proportion of their capacity to energy arbitrage; that is, to time shifting the energy supplied by wind and solar generators so that more of it is available when demand reaches peak levels.

The experience of operating Hornsdale Power Reserve already demonstrates that multiple smaller energy storage facilities, which will certainly include both batteries and small pumped hydro projects, located close to wind and solar generators, are almost certainly better suited to matching variable supply with varying demand than a single monster project located a thousand kilometres or more away, via multiple transmission lines which often reach saturation capacity when demand for electricity reaches peaks.

Finally, amongst the many reports released in the week before last Christmas, was one from AEMO, entitled *Integrated System Plan Consultation*. The document considers a number of different medium to long term futures for the electricity supply system constituting the NEM, including one with deeper emission cuts than have been contemplated by the current Australian government. The report did attract some media attention in January, and has since come under strong criticism in some quarters, with some commentators quoted as accusing AEMO of over-reach and "an audacious public grab for power". AEMO is required to think long term, and therefore to consider a wide range of possible futures, in order to do its job of managing the evolving electricity system. What AEMO was doing with the report was scenario planning, a activity which has a 50 year history in the energy industries, having been pioneered by the Shell Company in the late 1960s.[3]

[3] Shell's foresight was very timely, because a few years later, in 1973, the oil companies were hit with an almost completely unexpected fourfold increase in the price of crude oil.

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.