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NATIONAL ENERGY EMISSIONS AUDIT

National Energy Emissions Audit Report

February 2020

Providing a comprehensive, up-to-date indication of trends in Australia's energy combustion emissions

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Key points

- *On 4 January, bushfires caused the transmission line to trip between NSW and Victoria, causing NSW and ACT governments to appeal to consumers to reduce electricity consumption, wholesale prices hit the roof at $14,700 MWh and load shedding was narrowly avoided.*
- *On 31 January, violent storms tripped the transmission between Victoria and South Australia (SA) leaving SA to operate as a standalone grid, supply power to the Portland smelter with a majority of wind and solar generation, along with gas.*
- *Total annual gas generation in the National Energy Market (NEM) doubled between 2006 and 2011 and driven by unrealised assumptions that wholesale gas prices would fall, gas would be serve as a transition fuel under a carbon constrained market and electricity demand would continue to increase.*
- *There is no strong case for more gas generation in the NEM given the current 4.4 GW of combined cycle and 7.0 GW of open cycle (peaking) gas generators are used well below their capacity factors.*
- *Combined cycle gas plants should have capacity factors in the range of 70-90% and yet averaged just 29% over 2018-2019, rising to just 31% in the final 6 months of 2019.*
- *Under every scenario in AEMO's latest Integrated System Plan, gas generation declines.*
- *Were the NEM in need of more gas generation over the next couple of years, the existing fleet of gas plants should be technically capable of supplying it (to the equivalency of around 7% of NEM generation).*
- *Total share of coal power in the NEM went from 82% about 10 years ago to 74% three years ago and finally to 67% by December 2019.*
- *From 2018, increasing output from rooftop solar was sufficient to meet all of the (relatively modest) growth in total electricity consumption in the NEM, with the result that electricity supplied through the NEM grid stayed almost exactly constant.*

INTRODUCTION

Welcome to the February 2020 issue of the NEEA Report, presenting electricity related data updated to the end of January 2020. Details on data sources and methods are included in the appendix.

This issue then examines the emissions associated with extracting and processing coal and gas for export from Australia. Domestic emissions caused by Australia's large coal and gas exports are estimated to have been 13% of Australia's total emissions in 2016-17. The significant emissions from gas consumed in the Queensland LNG projects are shown in the context of other gas consumption.

Turning to electricity, data to the end of December 2019 show the continued steady growth in renewable generation and associated fall in emissions. Two new graphs are included, showing the ten-year trend in total renewable generation by state and the consequent renewable share of total generation in each state. These data allow ready assessment of how states with formal renewable targets are progressing towards their targets, and makes it easy to compare their performance with those of states without targets.

OVERVIEW OF MAIN TRENDS

Update on electricity generation and emissions

Figure 1 shows that trends across the NEM as a whole in electricity consumption, emissions, and emissions intensity of generation were essentially unchanged again during January. Consumption of grid supplied electricity is flat or decreasing very slowly, but is gradually increasing when electricity supplied by rooftop solar is included.

Figure 1

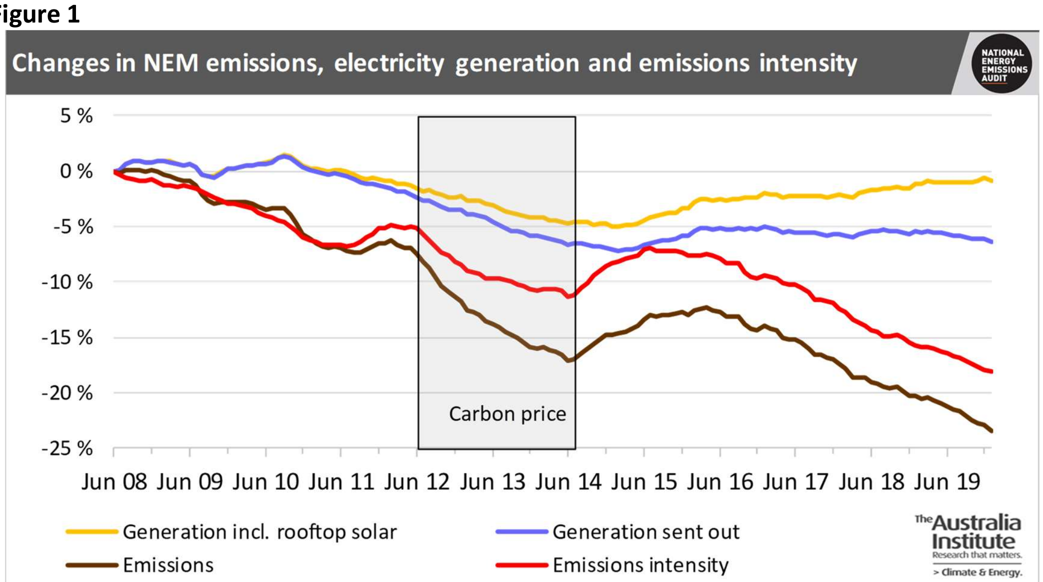


Figure 2

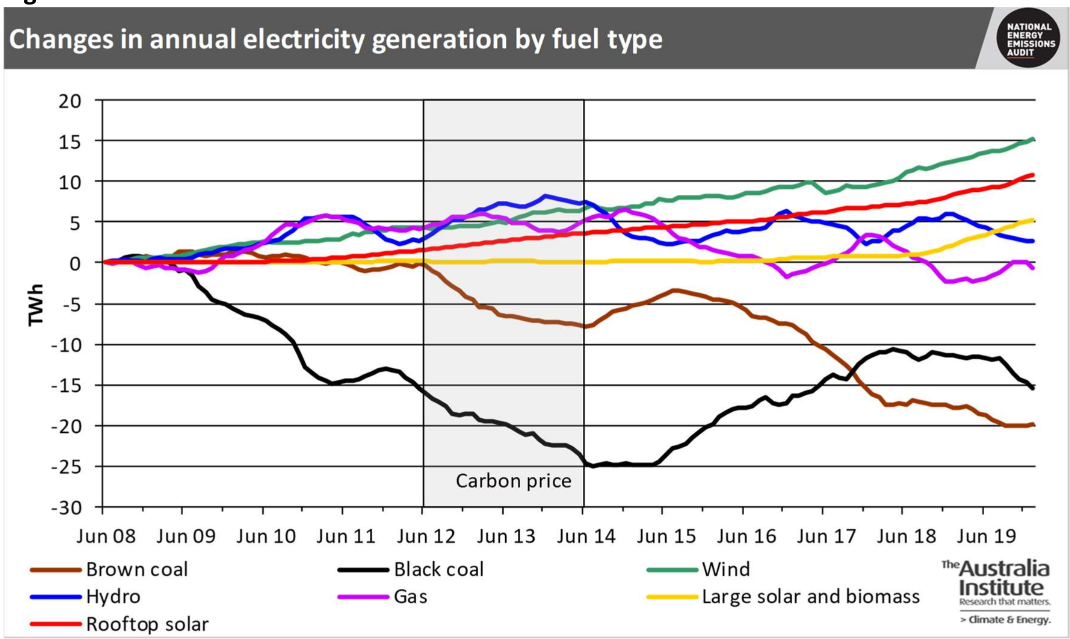
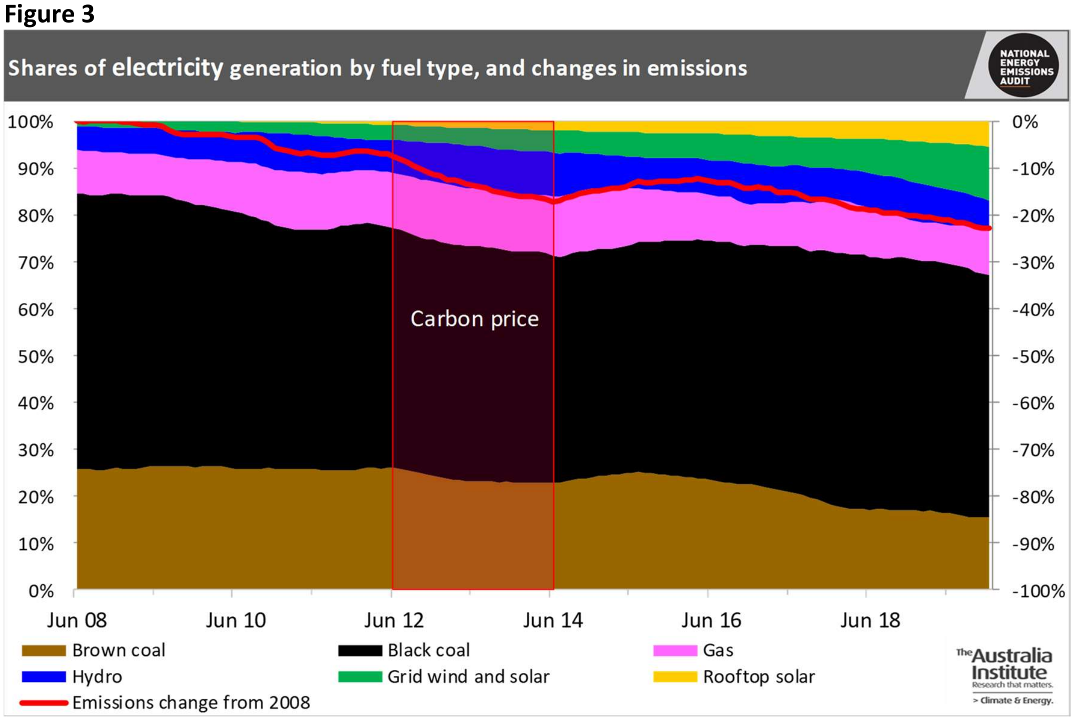


Figure 2 shows that wind and solar generation continue to grow, while coal and, to a somewhat lesser extent, gas generation decrease. The same data are presented in a different format, as shares of total generation, in Figure 3.

Figure 3



Seen together, these three graphs summarise the first ten years of the electricity transition in the NEM, which fall into four separate periods.

2008 to 2010

- Growth in demand for electricity slowed and finally stopped altogether.
- Annual electrical energy supplied through the NEM reached its maximum level during 2010, marking the culmination of over a century of almost unbroken growth in consumption of electricity in each of the five states which make up the NEM grid.
- A surge in construction of gas generators ended, with over 1 MW of combined cycle gas capacity and over 2 MW of open cycle capacity commissioned during 2009 and 2010.
- Overall, total annual gas generation in the NEM doubled between 2006 and 2011.

These investments in gas generation were driven by a number of assumptions assumptions/expectations: firstly, that wholesale gas prices would fall to very low levels; secondly, that gas generation would be an important bridge in the transition to a low emission future and thirdly that electricity demand would continue to grow.

2010 to 2014

- Demand for electricity fell sharply, at an average rate of more than 1.5% per year.
- From 2009 to 2014, retail electricity prices for residential and other small consumers almost double in real terms in most NEM states, mainly driven by the imposition of much higher network costs, and, during 2012 and 2014, the imposition of a carbon price on generators.
- The short-lived carbon price, which allowed Hydro Tasmania and Snowy Hydro to profit at the expense of coal generators, by generating well above their respective long term average reliable output levels for the two years the price was in place, caused a sharp drop in emissions, reversed as soon as the price was removed.
- While higher prices were obviously an incentive to reduce consumption, they were not the only factor driving demand reductions. Other important factors included:
  - closure of two aluminium smelters and several other large industrial consumers, precipitated by a number of economic and business related factors, of which higher electricity prices were only one; and
  - large increases in the energy efficiency of electrical appliances and equipment, mainly attributable to the imposition of regulated minimum energy performance standards, such as the phase-out of incandescent light bulbs.

2015 to 2017

- Annual electricity consumption at first increased, because of the conversion of the two largest coal seam gas producing areas of Queensland from gas engines to electric motors to power the enormous numbers of pumps and compressors needed to extract the gas.
- Government-created policy uncertainty caused a near freeze on new investment in renewable generation. This meant that most of the increased demand was supplied by black coal generation, causing emissions to rise sharply.
- Black coal generation in both New South Wales and Queensland continued to increase as a series of higher emission brown coal power stations were closed: first Northern power station in South Australia, then two smaller brown coal stations in Victoria, and finally Hazelwood.
- Emissions, however, decreased because black coal power stations are less emissions intensive than brown coal plants.
- Parliamentary compromise in 2015 over the future of the Renewable Energy Target legislation led finally to a surge of investment in new wind farms during 2016 and 2017.

2018 to present

- Many new wind farms came on-line, accompanied, for the first time, by large numbers of new solar farms.
- This new generation displaced, in varying proportions, black coal, brown coal and gas generation, resulting in a steady fall in emissions. In the year to the end of December 2019, the total share of electricity supplied by coal power stations was 67%, down from 74% three years previously and 82% ten years previously, while the share of gas was at the same level as ten years previously.
- In parallel with these changes, uptake of small (rooftop) solar generation accelerated across all size ranges, including residential scale and also, for the first time, larger commercial and industrial scale installations.
- Increasing output from rooftop solar was sufficient to meet all of the (relatively modest) growth in total electricity consumption in the NEM, with the result that electricity supplied through the NEM grid stayed almost exactly constant.
- Most recently, constraints on transmission capacity have started to limit the rate at which new wind and solar farms can connect, with consequent slowing of the growth in new renewable generation and the share of supply provided by renewable sources.

The future of gas generation in the NEM

In his supposedly agenda setting speech at the National Press Club on 29 January, the Prime Minister announced that the Commonwealth would be providing financial support for building new gas fired power stations. There is currently a total of 4.4 GW of combined cycle and gas fired steam capacity, and 7.0 GW of open cycle (peaking) capacity. Combined cycle generators are designed to compete with coal fired generators, operating with high capacity factors, say in the range 70% to 90%. During 2018-19 the combined cycle and steam plants together supplied just under 12 TWh, which implies an average capacity factor of just 29%, which rose to 31% over the last six months of 2019. The average capacity factor of the peaking plants was 8%, increasing to 9% in the subsequent six months. If the NEM needs more gas generation over the next few years, the existing fleet of combined cycle plants should be technically capable of supplying at least another 12 TWh, equivalent to 7% of NEM generation, even allowing for the impending closure of Torrens Island A, the oldest power station in the NEM. Why is more gas generation needed so urgently that it has to be subsidised by the taxpayer?

AEMO certainly sees no need for more gas generation capacity. In December it released the draft of its second Integrated System Plan (ISP) – the first was published in 2018. The draft models the evolution of the NEM from 2020 to 2042 using five different scenarios. The scenarios differ in their assumptions about rates of economic growth, costs of different types of generation, and the overarching emissions reduction policy framework, among other factors. For each scenario, demand for electricity follows a different path into the future, and the models are designed to show the least cost generation option to meet the projected demand under the respective scenarios.

Figure 4

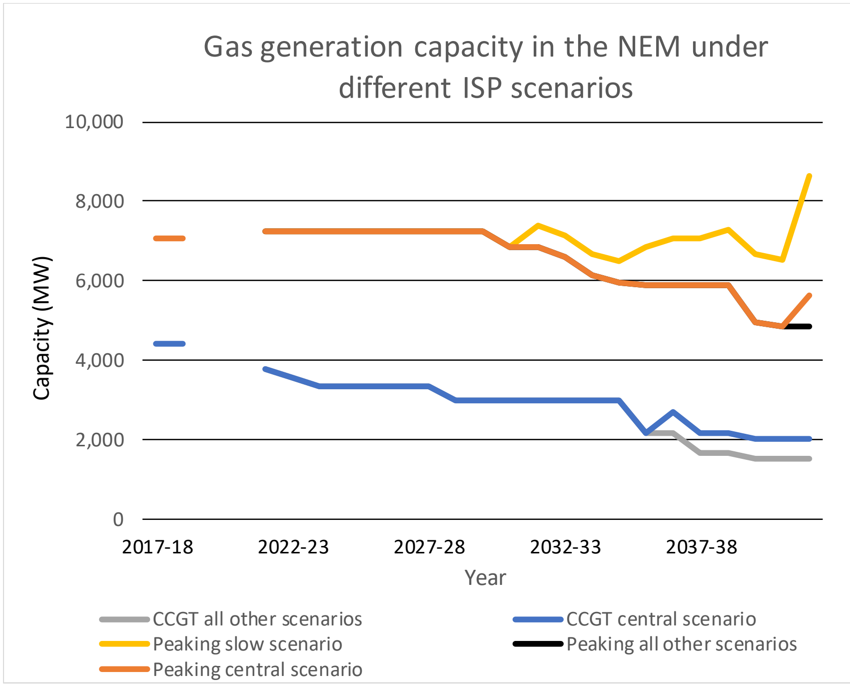
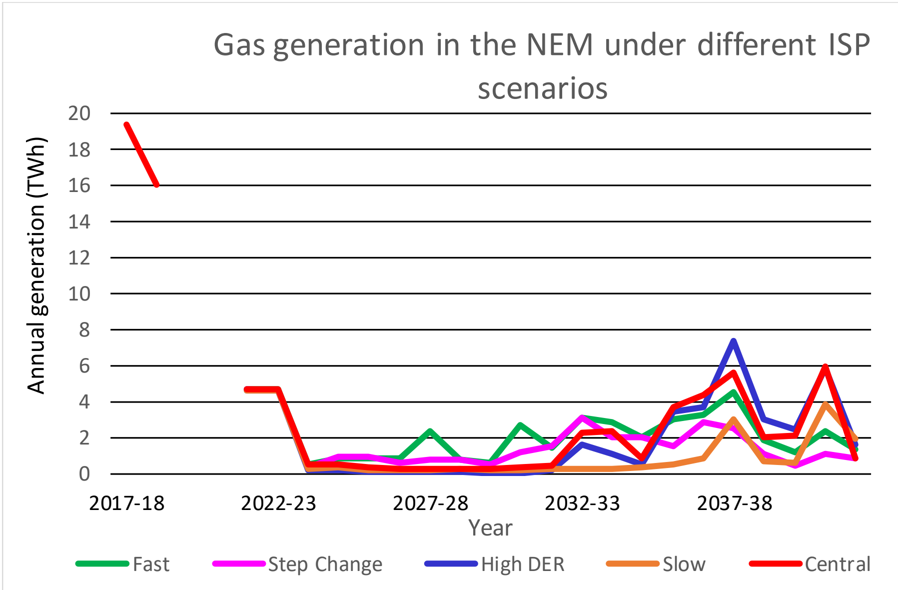


Figure 4 shows the projected capacity of gas generation in the least cost option for meeting demand under each scenario. With the exception of a major addition to peaking capacity in the last projection year of the Slow scenario, gas generation capacity declines steadily under all scenarios, and is never more than it is today. It is possible that some of the older gas generators may be retired over the next 10 to 15 years. If that occurs, existing market rules and procedures are designed to ensure that investors make an orderly and timely replacement, if needed. There is no case at all for new, subsidised gas generation.

The ISP modelling yields even more sobering results for the quantities of electricity supplied by the fleet of gas generators. These results are shown in Figure 5, and require no further comment.

Figure 5



January was a challenging month in the NEM

Every year summer, and particularly the six weeks covering January and early February, is always the most challenging time for all those responsible for operating the NEM electricity system. Annual peak demand for the NEM as a whole, and in every state except Tasmania, invariably occurs during this period, and the potential supply of electricity is eroded because of the unavoidable effect of higher ambient temperatures on the efficiency of thermal generators (a consequence of the Second Law of Thermodynamics). High temperatures also cause significant reductions in the output of solar farms and rooftop solar systems. AEMO staff, together with the operators of power stations, transmission grids and distribution networks, put a lot of effort during the winter months into planning for the summer to come.

The scale of the bushfires this summer caused enormous damage to distribution networks in rural areas, causing many thousands of customers to lose electricity supply, many for several weeks. In addition, on two days in particular, the system as a whole faced very serious challenges.

Saturday 4 January: New South Wales

This was an exceedingly hot day in New South Wales with bushfires burning right across the south east of the state. Demand in the state reached an extremely high level (possibly the highest ever level for a Saturday, until it was exceeded four weeks later on 1 February). In the middle of the afternoon, just an hour or so before the expected (and actual) peak demand in New South Wales, a severe bushfire burnt under and around the major transmission lines and switching stations in the Talbingo/Upper Tumut area of the Snowy Mountains. These are a key part of the main transmission link between New South Wales and Victoria; the fire caused this interconnector, followed by several adjacent transmission lines, to trip out. At the time, exports from Victoria to New South Wales were running at a high level; the transmission trips also cut off access to all generating capacity south and west of Yass, which includes the large Uranquinty gas peaking generator and several solar farms. The sudden loss of supply was equivalent to between one and two of the largest coal fired units, or most of the output from Mount Piper power station, being suddenly lost.

In response, imports from Queensland increased to the maximum available capacity, large and rapid increases in supply came from the Tallawarra and Colongra gas fired stations and an unknown amount of managed demand reduction also occurred. Both the New South Wales and ACT governments also issued public appeals to consumers to reduce their electricity consumption. In the end, load shedding was avoided, but the spot wholesale price shot up to the maximum allowable level of $14,700 per MWh and stayed at or very close to that level for about two hours.

Friday 31 January: New South Wales, Victoria and South Australia

On this day, total NEM demand reached its second highest ever level, measured on a trading interval basis, of 35,560 MW, just over 200 MW below the historic peak level which occurred on 29 January 2009 (nine days before the Black Saturday bushfires). Peak demand in Victoria reached the highest level of the summer to date and in New South Wales the second highest level. From around the middle of the day, Victoria was hit by a series of violent storms. In the early afternoon, before demand had reached its maximum level, one of these storms blew down six transmission line towers, west of Geelong, on the double circuit 500 kV line running from Melbourne to Portland. This line is both the only source of supply to the Portland aluminium smelter and a key part of the principal interconnector between Victoria and South Australia.

At the time of the transmission collapse it was quite windy in South Australia, while temperature and electricity demand had dropped, allowing significant export volumes to Victoria. This in turn allowed Victoria to export New South Wales, allowing both states to meet the rapidly climbing demand for electricity.

The immediate response in both Victoria and New South Wales was a sharp drop in frequency, which the system managed well, and immediate increases in hydro and gas generation to make up the supply deficit in both states. As the afternoon wore on, coal generators were also able to increase output to meet the growing demand (in Victoria coal was already at maximum capacity). Spot wholesale prices in both states rose to their maximum level on a number of occasions during the three hours following the disruption.

In South Australia, with its much lower level of demand for electricity, the instantaneous effect of the incident was relatively much larger than in the other two states, and was a sudden large oversupply of electricity. System frequency shot up to a dangerous level, but both gas generators and wind generators, some of them reprogrammed following the blackout events in 2016, powered down as required without any disruptions to supply in the now isolated South Australian grid.

It is likely to be several weeks before any synchronous connection with the rest of the NEM is restored, via a temporary repair to the transmission line, and presumably much longer before the damaged section is fully rebuilt. South Australia has been operating as a small standalone grid, relying on gas, wind and solar generation. In order to be certain that the system remains in a secure operating condition throughout this period, AEMO has been requiring many wind generators to curtail their output on many occasions, and it is also directing gas generators to operate at times when they probably would not, because of low spot prices. Over the six days from Saturday 1 February to Thursday 6 February, the supply mix in South Australia was 52% gas, 16% wind, 3% grid solar and 29% rooftop solar. Presumably because of the large overhang of curtailed potential wind generation, the wholesale price has been very low, averaging around $6 per MWh over the whole six days.

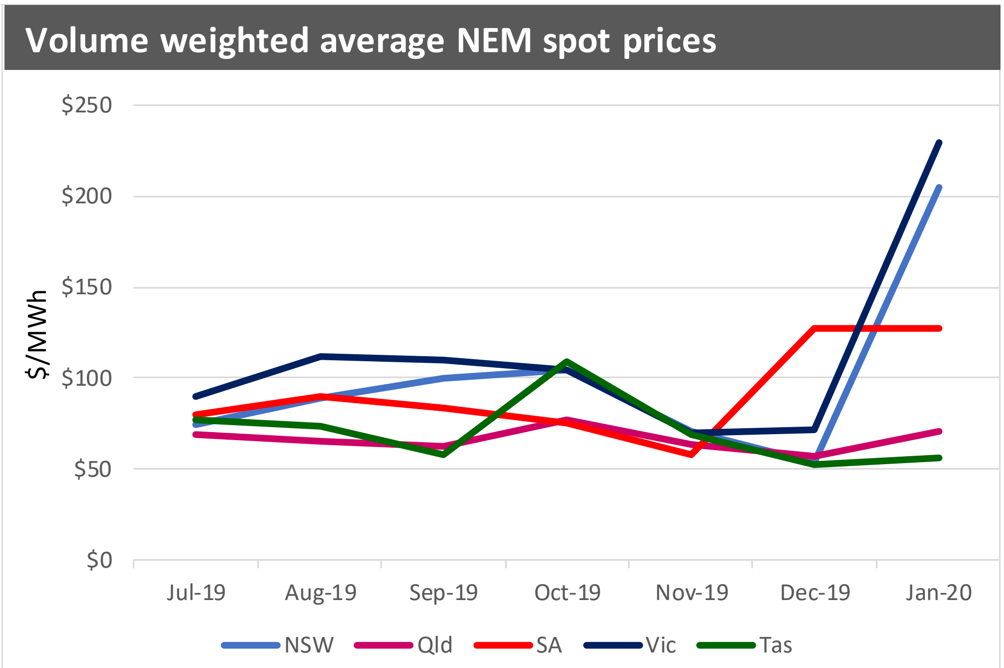
The occurrence of such a major transmission failure, just a few hours before total demand in the NEM reached its second highest ever level, presented an extraordinary challenge to the operation of the NEM system. Informed commentators have generally concluded that AEMO and the relevant transmission system operators all did outstandingly well to ensure that the only disruptions to supply were those experienced, for a relatively short period, by the Portland aluminium smelter and other consumers nearby, who are those most directly exposed to the failure. It is noteworthy that this achievement, and the continuing ability of the South Australian system to operate in isolation, have received almost no attention in general news coverage, or amongst political leaders. It is clear that all responsible parties have learnt from, and responded well to, the South Australian system black event in 2016, but the public response to this recent event is obviously a stark contrast with the hysterical response to the 2016 event.

2019-20 NEM wholesale prices

Figure 6 shows volume weighted monthly average spot wholesale prices in each NEM region since July 2019. The effect of the events described above on average prices in

New South Wales and Victoria is obvious. In South Australia, one of its half dozen highest ever daily peak demands was experienced on 19 December, which explains the high average price during December, while the events described above are responsible for the very high average prices for January in New South Wales and Victoria. South Australia sees low prices during October and November, when generally fairly mild sunny weather enables the share of rooftop solar in total supply to each particularly high levels.

Figure 6



Acknowledgment

Articles by Paul McArdle and Allan O'Neil, published on the WattClarity site, we a great help in preparing the account of the disruptive events in the NEM during January

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.