Australian electricity market: struggling to cope with de-carbonisation

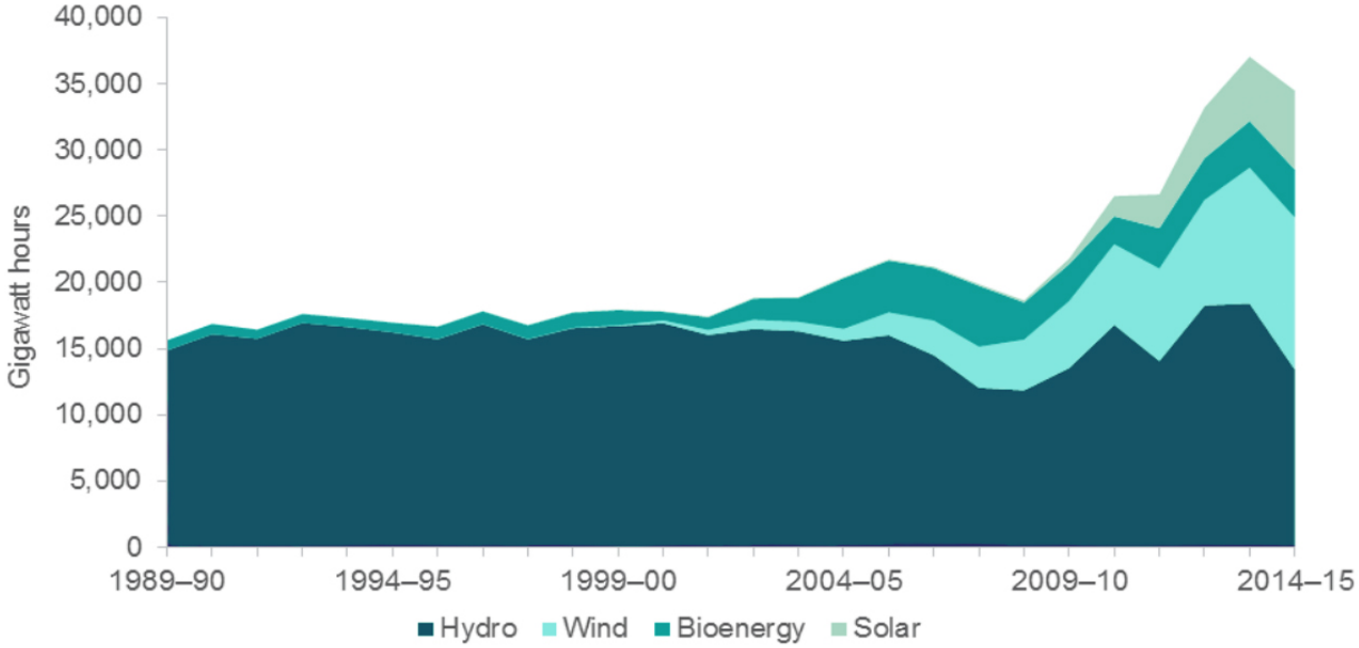
Posted on 2 June 2017 by Kathryn Porter

The words “Australia” and “energy crisis” are increasingly being used together, so it is interesting to consider how an energy rich country has found itself on the brink of energy chaos, with blackouts and brownouts occurring over the past year and a half. Australia’s National Electricity Market (NEM) is under severe pressure due to a poorly managed transition to renewable generation, closure of coal plants, and a growing dependence on gas at a time of rising gas prices.

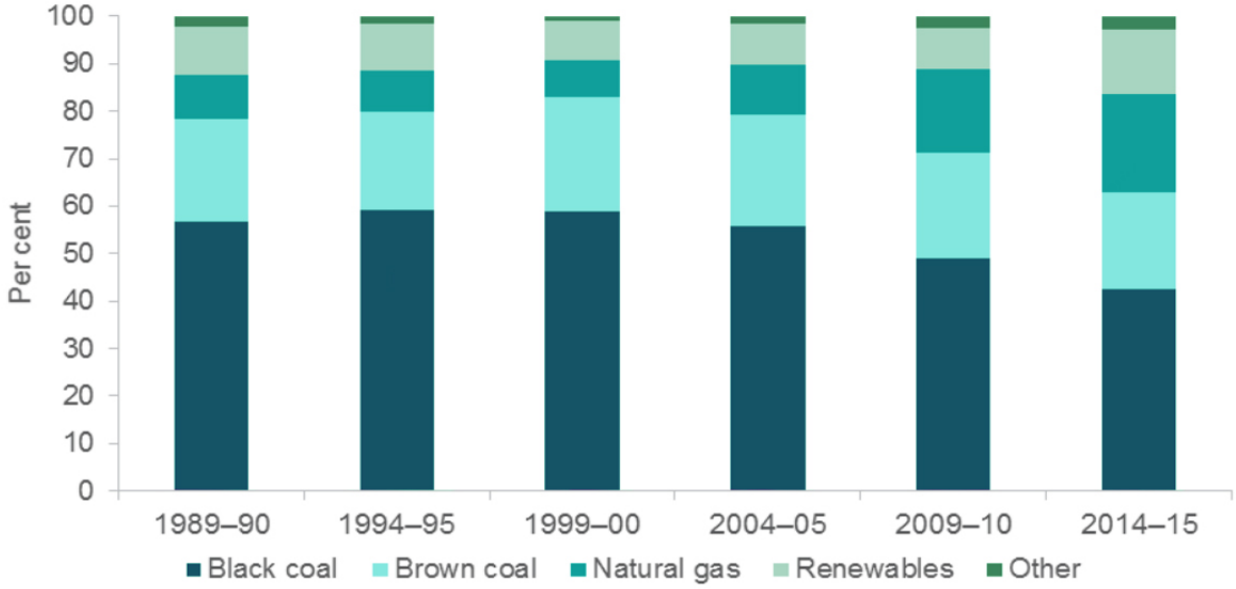
Traditionally, most electricity generation in Australia came from coal, gas and hydro, but now wind and solar account for 7% of all generation and in South

Australia, wind alone accounts for almost 50% of all electricity consumed. About 15% of Australian households have rooftop solar, up from under 1% in 2007.

Australian electricity generation from renewable sources



Australian electricity generation fuel mix



Source: Department of Industry, Innovation and Science, Australian Energy Statistics

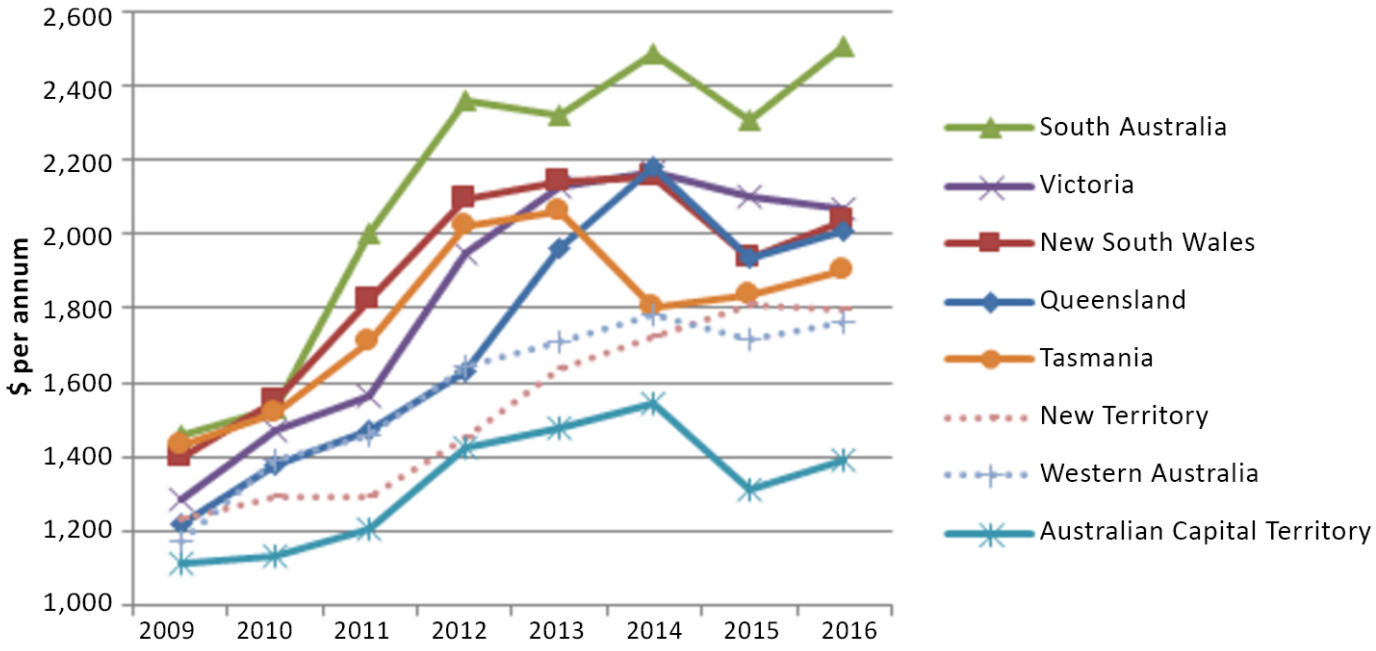
According to a recent report from the Grattan Institute, the past 18 months have seen new vulnerabilities in the Australian electricity market emerge.

September 2016 saw a state-wide blackout in South Australia, the first state-wide blackout since the formation of the NEM in 1998, and smaller blackouts/instances of load shedding have been seen in Victoria, Western Australia and New South Wales since late 2015.

The failure of Tasmania's electricity interconnector to Victoria in December 2015, left the state unable to import or export electricity for six months. As this coincided with a drought that reduced hydro output, the state was forced to import diesel generators in order to maintain supply, and even then some businesses were required to make significant demand reductions.

The September 2016 blackout caused significant economic damage (with some estimates as high as US$280 million). But even when the grid is functional, South Australia has the highest energy prices in the country and the average household pays over US$1,500 a year for power.

Changes to electricity prices in Australia July 2009 to July 2016 as estimated annual bills (nominal, inc GST) for electricity regulated/standing offers, 6,000kWh per annum, single rate



Source: Tariff Tracking Project operated the by St Vincent de Paul Society, in conjunction with Alviss Consulting

Capacity closures driving high prices and system instability

As increasing renewable generation pushed down wholesale prices, coal stations began to close, with 3.6 GW capacity closing between 2010 and 2016, and the 1,600 MW Hazelwood power plant which was capable of providing one quarter of Victoria's electricity needs shutting in April 2017. Even with prices now rising rapidly, further closures are scheduled.

This is triggering an unprecedented use of gas-fired generation, driving higher electricity prices on the back of high gas prices – despite being a significant gas producer, the majority of production is committed under long-term export contracts. The Australian Energy Market Operator (AEMO) has warned of possible gas shortages as early as the summer of 2018-19 if action is not taken by the market or by government.

During the summer of 2016-17, prices in all NEM states (except Tasmania) were twice those in the previous summer.

There are now concerns that there may be insufficient generation to meet peak demand in South Australia and Victoria next summer, meaning they will need to import power from other regions of the NEM if wind and solar are unavailable during peak times. However, despite plant closures and rising prices, the Grattan report describes the market as "un-investable" – investment in new generation, including in renewables, is stalling as the market waits for clear signals from government.

It's not just new capacity that is needed. With the closure of large units of synchronous generation, the stability of the power system is being undermined. Other technologies such as synchronous condensers, synthetic inertia controllers and large-scale battery storage could provide grid-stabilisation services, but these have not yet been adopted in Australia. (Although Elon Musk recently promised to fix South Australia's energy crisis in just 100 days by installing large battery farms.)

Indeed, the inertia provided by traditional generators has not historically been not recognised by the market, and ancillary services products are for longer response times of 5 minutes, 1 minute and 6 seconds – by comparison, National Grid in the UK has already created a market for frequency response services with sub 1-second response times to counter the impact of higher penetration of intermittent generation.

According to Grattan, South Australia has one of the highest levels of intermittent, non-synchronous electricity generation in the world, driven by the federal Renewable Energy Target (RET), and is particularly vulnerable if the interconnector with Victoria fails and South Australia is cut-off from the NEM. AEMO estimates that almost a quarter of the time South Australia would be unable to cope if unexpectedly cut-off, and for most of the rest of the time its ability to cope would be "uncertain". Clearly, more thought needs to be given to how the intermittency of renewable generation can be accommodated within the electricity system.

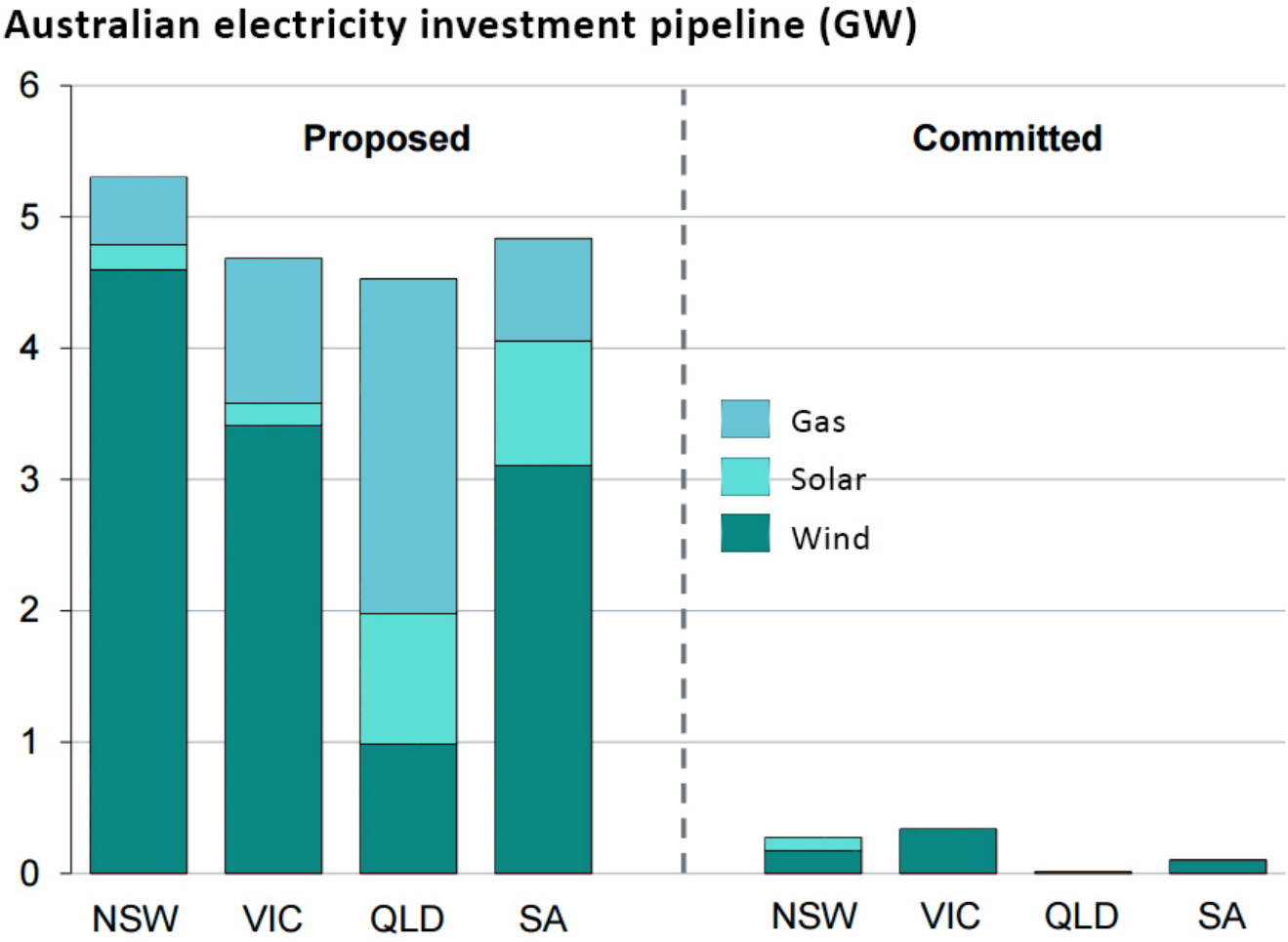
Confused policy initiatives risk exacerbating the situation

NEM wholesale prices have never provided full investment signals as hedging and ancillary services markets provide alternative revenue streams for generators, much as in the UK. Also in line with markets elsewhere, government subsidies have supported renewables projects and network investments are made outside the wholesale market but can have major consequences for potential new generation schemes.

Uncertainty over the future direction of government policy further complicates matters in a number of respects:

- Federal climate change policies are not currently sufficient to ensure Australia can meet 2030 emissions reduction targets;
- Different states have adopted different targets over different timeframes;

- The government has announced investments in new generation, with the potential for further investments in the future; and
- The South Australian Government has threatened direct intervention in the activities of the market operator.



NOTES: Potential new generation projects as at 27 February 2017. Proposed projects are those that have been publicly announced and may have completed initial feasibility studies, but have not yet received a Final Investment Decision (FID). Projects at the Committed stage of development have received a FID and have either started, or are expected to start, construction.

Source: AEMO

In response to potential capacity shortages, both the Federal and South Australian Governments have announced new direct investment in electricity generation – a development which risks destroying any ability the market had

left to provide appropriate signals for decisions on investing in new capacity and closure of old capacity. The Federal Government has announced feasibility studies for two pumped hydro projects, with up to 4,500 MW of capacity and the South Australian Government has announced funding for a new gas facility and one or more large-scale battery storage facilities as part of an emergency energy package.

The South Australian Government justified its decision to invest in a new gas facility saying:

> "The private sector is not building new generation. That is why government is stepping up and taking control of our energy future by investing in new generation."

The Government has sought to reassure the market that the new government-owned generation would only be used only for emergencies, but market participants are unconvinced: AGL Energy has labelled this "wishful thinking" and has abandoned its own plans to build a new gas-fired power station. New state-owned generation is likely to deter private investors meaning that even more taxpayer funded projects will be needed to support security of supply.

De-carbonisation must be properly managed to avoid serious threats to electricity systems

The Australian example is a further illustration of the dangers in pursuing uncoordinated de-carbonisation policies. Replacing large amounts of conventional generation with renewable energy without paying due attention to security of supply and grid stability presents risks that are more immediate and potentially more damaging than the emissions they seek to mitigate – the South Australia blackout did not only cause significant financial losses, it also put lives at risk when the back-up generators at a major Adelaide hospital

failed, and embryos at a local fertility clinic were lost.

In the meantime, South Australians are paying extremely high prices for their electricity while facing the risks of further blackouts, and indeed job losses, as lack of confidence in reliable baseload supply is causing heavy industry to consider re-locating outside the country.

South Australian blackout of September 2016

On 28 September 2016, South Australia was hit by an unusually violent storm, including at least 2 tornados, which was described by the Australian Bureau of Meteorology as a once-in-50-years event. The state was hit by at least 80,000 lightning strikes and wind damaged a total of 23 pylons on electricity transmission lines, including damage on three of the four inter-connectors connecting the Adelaide area to the north and west of the state.

The preliminary report from the Australian Energy Market Operator identified that problems started 90 seconds before the eventual failure.

- The first line to trip was a 66 kV line near Adelaide, and it was automatically reset.
- 47 later two phases of the 275 kV line between Brinkworth and Templers grounded.
- The Davenport–Belalie line then tripped, was automatically reset, but tripped again nine seconds later, so was isolated for manual inspection.
- One second later, the Hallett Wind Farm reduced output by 123 MW.
- Four seconds later, a third 275 kV transmission line, the Davenport – Mount Lock showed a fault.
- The damaged power lines caused 5-6 voltage glitches which stressed the ride-through capability (ability of a generator to remain connected during short periods of low-voltage conditions) of most of the wind farm capacity, causing 9 of them to shut down.
- Finally, all within one second, the Hornsdale Wind Farm reduced output by 86 MW, Snowtown Wind Farm reduced output by 106 MW, the Heywood interconnector flow increased to over 850 MW and both of its circuits tripped out due to the overload. Supply was then lost to the entire South Australian region, as the Torrens Island Power Station, Ladbroke Grove Power Station, Murraylink interconnector and all remaining wind farms tripped.

The result was a state-wide blackout, which started at 4pm and lasted at least 3 hours. Even after 8 hours, about 10-20% of demand could not be met due to damaged transmission infrastructure. It was 2 weeks before all power requirements in the state, could be met in full.

Restoration of power was hampered by difficulties with 2 black start generators that trouble restarting – one used a new start-up sequence that failed, while the other may have been struck by lightning.

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