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National Electricity Market update, data to September 2016.

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Introduction

This *CEDEX® Electricity Update* contains data for emissions from electricity generation in the National Electricity Market (NEM) up to the end of September 2016. All emissions data are reported as annual moving averages. This approach removes the impact of seasonal changes on the reported data. Annualised data reported in CEDEX® 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.

Electricity emissions update - data to 30 September 2016

Demand growth softening, small drop in emissions as renewable generation rises

Key points

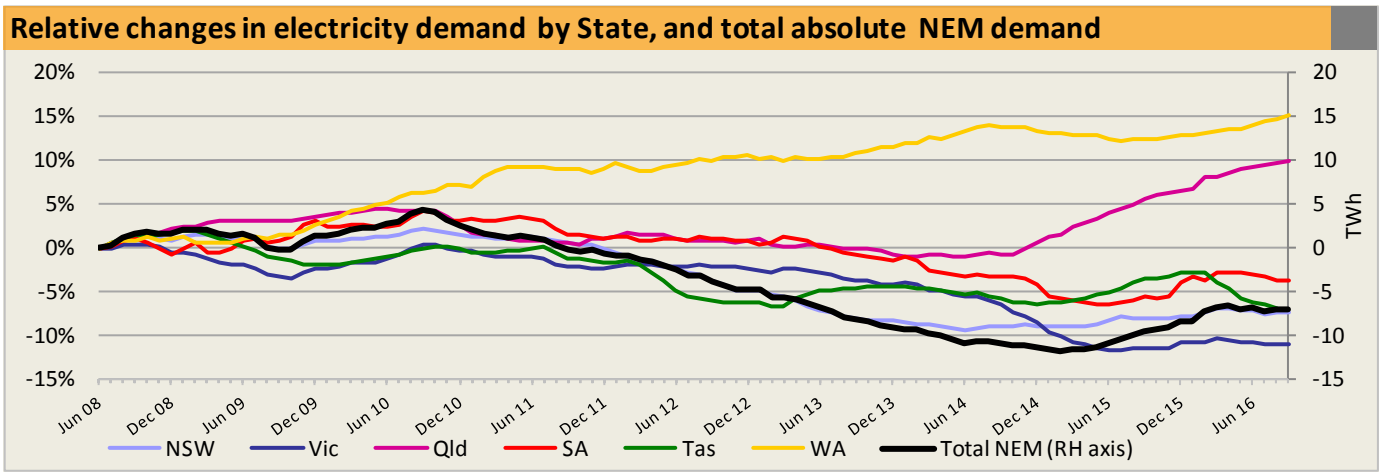
On average, total demand in the NEM was flat on average over the year to September 2016; however, strong growth continued in WA.

Total emissions from electricity generation in the NEM increased slightly in the year to September 2016, reaching a level 4.8% higher than in the year to June 2014.

Total coal generation also rose slightly to 75.9%, compared with a minimum of 72.3% in the year to July 2014. Gas generation fell again, as it has now been doing for almost two years. Both hydro and wind generation increased, so that total renewable generation reached 14.0%. Total annual wind generation reached its highest ever level, in both absolute terms and as a share of total NEM generation.

This issue of *CEDEX® Electricity Update* concludes with a discussion of supply mix and grid reliability issues, in the wake of the large black-out event in SA on 28 September.

FIGURE 1



Demand

In September, total annual demand for electricity was virtually unchanged in NSW, Victoria and SA. There was a continued fall in Tasmania as the supply cut-backs of last summer work through the annual total. Demand increased again in Queensland, with the overall outcome for the whole NEM being a very small increase. There has

now been no effective change in annual NEM demand for the six months since March. By contrast, demand in the WA South West Interconnected System (SWIS) increased quite strongly in the year to September (Figure 1). (Regular readers will note that WA data are now fully up to date with NEM data; this follows reporting changes implemented since the WA Independent Market Operator was merged with AEMO.)

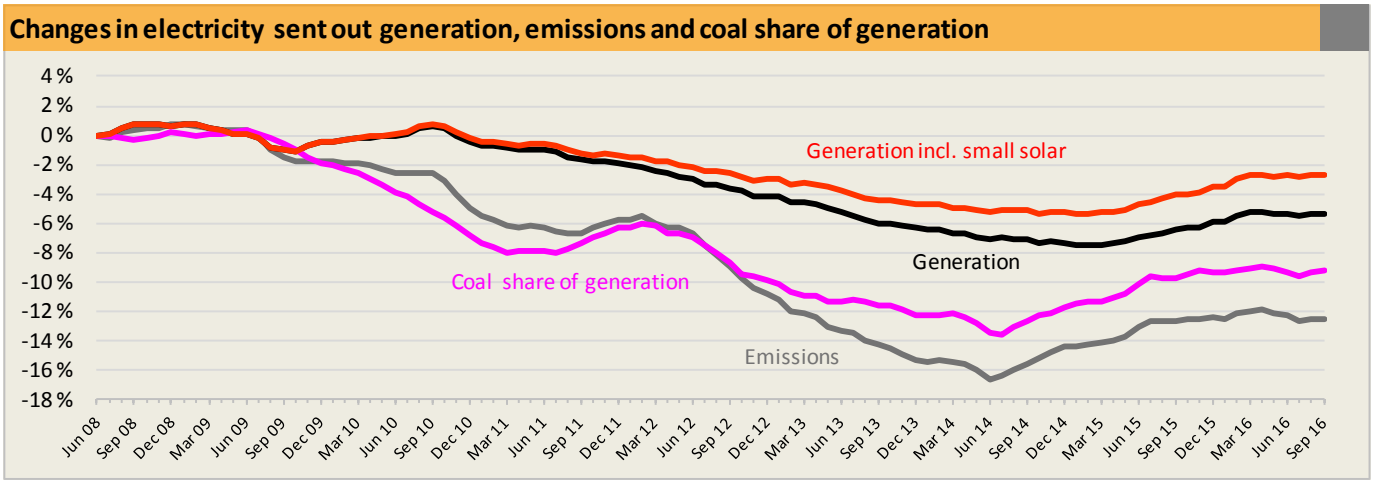
It is not immediately obvious why demand for electricity continues to grow so strongly in WA. Faster population growth is certainly not the immediate cause. The most recent ABS demographic statistics show that the WA population grew by 1.15% between March 2015 and March 2016. This was below the national growth of 1.38%, and much below the growth of 1.94% in Victoria (interestingly, the only state to grow at a rate above the national total).

Generation and emissions

Total annual NEM generation and emissions both increased slightly from August to September, in line with total annual demand (Figure 2). The coal share of total generation increased slightly, and consequently, emissions also increased slightly (Figure 3). For the first time in over a year, brown coal generation increased, though only slightly. Black coal generation also increased by a small amount. Black coal generators supplied 53.6% of total supply and brown coal generators supplied 22.3%, making a total coal share of 75.9%. Gas generation fell again, as it has now done for twenty two successive months, reaching a level of 10.1% of total NEM generation.

FIGURE 2

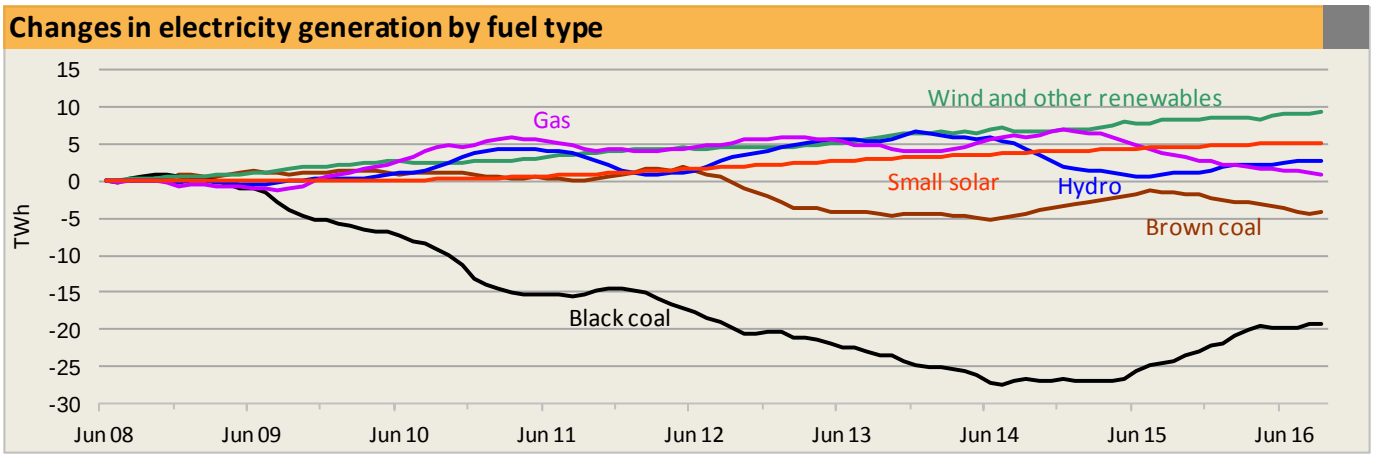
Changes in electricity sent out generation, emissions and coal share of generation



Both hydro and wind generation also increased in September, bringing total renewable generation for the year to 26.0 TWh, equal to 14.0% of total NEM generation, the highest level since August 2014. For the fourth successive month, total annual wind generation set a new record; in the year ending September it reached 10.8 TWh, equal to 5.8% of total generation in the NEM. For comparison, the hydro share was 7.8%. Part of this steady increase in wind generation is attributable to the commissioning of the first turbines at two new windfarms, Ararat in Victoria and Hornsdale in SA. Both are contracted by the ACT government to contribute to its 100% renewable contracted electricity supply by 2020. These two projects ended a gap of 16 months with no new windfarms, since the first machines at Bald Hills, in Victoria, were commissioned in February 2015. The halt in windfarm development was the consequence of considerable policy uncertainty regarding the RET under the Abbot government. While uncertainty was ended with the passage of legislation for a lower target, it is notable that the lower RET is still to deliver any new wind capacity. The ACT-linked wind farms are all additional to the RET – the potential certificates

from ACT contracted windfarms are surrendered – and therefore add to the emissions abatement achieved through the national RET policy..

FIGURE 3



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Before moving to the SA blackout it may be useful to present some figures on generation in the four mainland NEM states, which constitute the synchronously connected NEM grid. (Tasmania is connected by a DC link, and so is not always synchonised.) One of the responsibilities of AEMO, as grid operator, is to maintain the supply frequency within a narrow band around 50 cycles per second across the entire grid, stretching from Cairns in far north Queensland to Port Lincoln in the west of SA. During the past year, the maximum 30 minute trading interval demand across the whole mainland NEM in summer was 31.6 GW on 13 January and in winter 30.4 GW on 27 June. AEMO's 2016 *Statement of Opportunities* records that total capacity installed in the mainland NEM is currently 44.4 GW, of which 40.8 GW was dispatchable (coal, gas, hydro) and 3.6 GW (8%) non-dispatchable (wind and a little large solar). Of the total dispatchable, 5.7 GW (13%) is hydro, mainly in NSW and Victoria, and 6.2 GW (14%) is Open cycle Gas Turbine, mainly in Queensland and SA. Both of these generation types are designed to respond quickly to changing levels of demand. *Prima facie*, the mainland NEM at present has adequate capacity of all generation types to meet demand at all times, and this is the broad conclusion of the *Statement of Opportunities.*

The South Australian blackout

As reported in the August issue of *CEDEX® Electricity Update*, SA peak demands this year were 3.0 GW in summer and 2.5 GW in winter. AEMO states that the state currently has 1.70 GW of combined cycle and steam turbine gas generation and 0.92 GW of open cycle gas turbine generation. In addition, SA is connected to the other mainland NEM states through the AC, i.e. synchronous, Heywood interconnector, the capacity of which has recently been upgraded to 0.65 GW.

Several years ago AEMO established its Future Power System Security program. In its August 2016 program *Progress Report*, it explains:

> "AEMO established the FPSS program to formalise and accelerate the work it has undertaken in the last few years to address operational challenges arising from the changing generation mix. If left unaddressed, these challenges will test the efficiency and adequacy of current operational and market processes. The FPSS program focuses entirely on power system security. It aims to adapt current processes to address immediate risks, while promoting solutions to maintain power system security over the next 10 years. To date, AEMO has not identified any NEM-wide power system security concerns during normal operation."

The *Report* goes on to state:

> "Initial challenges are more acute in South Australia, due to the combination of its generation mix and risk of separation from the rest of the NEM. The risk of separation has itself not changed, however, the potential consequences have."

Related to, but distinct from, this program AEMO has published a number of reports under an agreement with the government of South Australia on issues specific to that state, called South Australian Advisory Function reports. The August 2016 *South Australian Electricity Report* contains an extensive discussion of the reliability of supply under circumstances where supply through the Heywood interconnector is lost, including, in the Executive Summary, the following statement:

> "In the rare event of the unexpected concurrent loss of both Heywood Interconnector lines, there is a high risk of a region-wide blackout in South Australia. South Australia has separated from the rest of the NEM due to such non-credible contingency events four times since 1999. The likelihood that a region-wide blackout would follow a non-credible islanding event has increased as the region has become more reliant on energy imports, and wind and rooftop photovoltaic (PV) generation, to meet demand."

It is possible that this, or another statement like it, may have provided a pretext for commentators, unaware of AEMO's work on system security, to voice doubt and speculation on renewable generation.

Loss of the two Heywood Interconnector lines was not what occurred on 28 September. What did occur, as clearly set out in the preliminary report by AEMO, released on the morning of 5 October, was loss, over a period of 40 seconds, of sections of three of the four major transmission lines running between Adelaide and Port Augusta. Two of the lines were a double circuit, i.e. two lines on the one set of towers, and this set of towers is the one which most of the published photos show. These lines provide the link between the now closed Northern and Playford coal fired power stations, in the north of the state, and the main load centre, in and around Adelaide. About two thirds of the state's wind generating capacity is also linked to major load centres through these lines, as is the Murraylink DC Interconnector. Should a new link to NSW be built, geography means that it would almost certainly be linked to Adelaide through these lines, or a new line following a similar route. The lines which were damaged constitute a large part of the spine of the South Australian transmission system (the other part being the lines to the south east of the state which form the SA section of the Heywood Interconnector).

The National Electricity Rules (Rule 4.2.3) describe an event such as occurred as a non-credible contingency, defined in the following terms

> "(e) A non-credible contingency event is a contingency event other than a credible contingency event. Without limitation, examples of non-credible contingency events are likely to include:
>
> (1) three phase electrical faults on the power system; or
>
> (2) simultaneous disruptive events such as:
>
> (i) multiple generating unit failures; or
>
> (ii) double circuit transmission line failure (such as may be caused by tower collapse)."

Thus what happened is explicitly anticipated in the Rules as the most severe possible (and by implication very rare) type of event.

AEMO reports that immediately prior to the event, power was being supplied to consumers in the state from the following groups of generators and interconnectors:

wind generators north and west of Adelaide	579 MW	32%
wind generators south of Adelaide	304 MW	17%
gas generators around and to the south of Adelaide	330 MW	18%
Interconnectors	613 MW	33%

AEMO states that "pre-event ... there was no credible risk of separation of SA from the National Electricity Market (NEM)". However, as described above, a non-credible contingency event occurred. The immediate consequence was that 315 MW of 579 MW being provided by wind generators north of Adelaide, and connected to the damaged transmission lines, i.e. 17% of total demand at the time, went off-line within 42 seconds of the first line failure.

The near instantaneous loss of 17% of supply would be an extremely challenging emergency for any electricity supply system. The rate of change of frequency was too fast to allow large scale controlled load shedding to avert overloading. Consequently the automatic protection systems caused Heywood, the main interconnector to Victoria, to trip out, followed within 0.2 seconds of all gas and wind generators still connected. The result was what is called a region-wide blackout. Why this wind generation went off-line is not known and AEMO does not speculate. Others have suggested that the protection settings on the relevant wind generators may have been "too conservative", i.e. unnecessarily sensitive, meaning that the generators were tripped out when they did not need to be. If this were correct, the trip would not have been caused by the wind generators *per se*, but on the way in which they were being operated. The correct answer will not be known until AEMO completes its full incident report.

This time last year the now closed Northern power station was generating on average an output of around 250 MW most days. It is highly likely that it would have been affected by, and responded to, a sudden large loss of load in exactly the same way as the windfarms, with the same ultimate consequence. Furthermore, contrary to some uninformed comments, there was significant gas fired generation capacity available but not being used at the time of the failure. Three of the four units at Torrens Island B were generating 246 MW in total, but had full capacity of 595 MW available, while two of the fast response Open Cycle Gas Turbine plants, also located close to Adelaide, were not generating but had 334 MW available.

There are well defined, but very seldom used procedures for restoring supply after a total blackout. The AEMO report describes in detail how these complex and difficult processes were implemented. The preferred procedure

was not followed because the gas turbine generator being paid to provide black start services was unable to supply the full contract power level. This meant that first supply was established through the Heywood Interconnector and the first customers were reconnected less than three hours after the blackout. Throughout the night gas generators were progressively brought on-line, followed by windfarms unaffected by the transmission line failures. AEMO estimates that by midnight on the Wednesday the load was about 60% of its day-ahead forecast level expected prior to the event, and by 9.00 the following morning it had reached over 80%. Given the magnitude of the transmission line failure, not to mention ongoing local storm and flood damage to the low voltage distribution network, the speed with which electricity supply was restored across most of South Australia is a tribute to the skill and hard work of AEMO and all participants in the electricity supply industry in the state.

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