Australia’s Electricity Generation

Dr Mark Ho
Australian Nuclear Science and Technology Organisation
IAEA SMR-TWG meeting April 2018
Quick Facts

- 25 Million people
- 7.7 million km\(^2\)
- Coast dwelling
- GDP: 1.482 trillion USD (13\(^{th}\))
- E-consumption 223.6 billion kWh (2015 est.)
- Total Generation Capacity ~ 60 GW
Electricity and Gas Network

Source: Australian Electricity Market Operator (AEMO) 2016-17 transmission congestion heat map
Electricity Consumption

Live Electricity Consumption
sponsored by ECA

Time: April 17th 8:50pm Eastern Std. Time.

SA state blackout, September 28th, 2016

<table>
<thead>
<tr>
<th>State</th>
<th>historic high [MW]</th>
<th>historic low [MW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW</td>
<td>14835</td>
<td>5114</td>
</tr>
<tr>
<td>VIC</td>
<td>10572</td>
<td>3271</td>
</tr>
<tr>
<td>QLD</td>
<td>9605</td>
<td>4037</td>
</tr>
<tr>
<td>SA</td>
<td>3441</td>
<td>11</td>
</tr>
<tr>
<td>WA</td>
<td>2451</td>
<td>1285</td>
</tr>
<tr>
<td>TAS</td>
<td>1910</td>
<td>524</td>
</tr>
</tbody>
</table>

Snapshot of peak usage.

Live Supply & Demand
Mon 16 Apr, 17:50 (NEM Time)

- WA: Black Coal (6912 MW), Liquid Fuel (0 MW), Other (N/A), Gas (N/A), Large Solar (N/A), Demand (AEMO Operational) (N/A), Demand (The AEMO don't see) (N/A), Battery Storage (N/A), Demand (Battery Charging) (N/A)
- TAS: Black Coal (6912 MW), Liquid Fuel (0 MW), Other (N/A), Gas (N/A), Large Solar (N/A), Demand (AEMO Operational) (N/A), Demand (The AEMO don't see) (N/A), Battery Storage (N/A), Demand (Battery Charging) (N/A)
- SA: Black Coal (6912 MW), Liquid Fuel (0 MW), Other (N/A), Gas (N/A), Large Solar (N/A), Demand (AEMO Operational) (N/A), Demand (The AEMO don't see) (N/A), Battery Storage (N/A), Demand (Battery Charging) (N/A)
- VIC: Black Coal (6912 MW), Liquid Fuel (0 MW), Other (N/A), Gas (N/A), Large Solar (N/A), Demand (AEMO Operational) (N/A), Demand (The AEMO don't see) (N/A), Battery Storage (N/A), Demand (Battery Charging) (N/A)
- NSW: Black Coal (6912 MW), Liquid Fuel (0 MW), Other (N/A), Gas (N/A), Large Solar (N/A), Demand (AEMO Operational) (N/A), Demand (The AEMO don't see) (N/A), Battery Storage (N/A), Demand (Battery Charging) (N/A)
- QLD: Black Coal (6912 MW), Liquid Fuel (0 MW), Other (N/A), Gas (N/A), Large Solar (N/A), Demand (AEMO Operational) (N/A), Demand (The AEMO don't see) (N/A), Battery Storage (N/A), Demand (Battery Charging) (N/A)

Total Supply: 1734 MW
Total Demand: 7959 MW
Network Structure

Transmission

Voltage limit: 132kV ±10%

132 kV

Distribution

Voltage limit: 33kV / 11kV ±6%

33 kV

11 kV

Retail

Voltage limit: 400V (three-phase, 230V single-phase) +10% -6%

400 V

Source: Professor John Fletcher (UNSW)
Market players in Australia

- Generators
  - Delta, TRUEnergy, AGL-Macquarie

- Transmission network operators (275 kW)
  - Transgrid, Power link

- Distribution network operators (33 kW)
  - Endeavour, Ausgrid, Essential Energy

- Retailers
  - AGL, Origin, EnergyAustralia

Source: Professor John Fletcher (UNSW)
Electricity costs

Each dollar paid in an electricity bill is distributed as follows (approx):

- Generation – 20 cents
- Transmission – 20 cents
- Distribution – 40 cents
- Retailer – 20 cents

What does this mean?

Only 20% of the bill buys the energy used in each household.

Source: Professor John Fletcher (UNSW)
NEM coal generation fleet operating life to 2050, by 50th year from full operation or announced retirement (AEMO)
NSW thermal generation outlook

MW Nameplate Capacity

2010 2020 2030 2040 2050

*Adapted from submission by Cape Otway Associates to Finkel Inquiry, June 2017

Graphics: Barry Murphy.
Renewables & Storage

ANU finds 22,000 potential pumped hydro sites in Australia

21 SEPTEMBER 2017

The Australian National University (ANU) has completed an audit of 22,000 potential sites across Australia for pumped hydro energy storage, which can be used to support a secure and cheap national electricity grid with 100 per cent renewable energy. The zero-emissions grid would mainly rely on

Fast tracking the development of a few of the best sites by 2022 could balance the grid when Liddell and other coal power

For journalists

Current domestic gas price: $7.5 / GJ AUD
AEMO future planning

Source: AEMO
Climbing Costs

Wholesale energy prices double in a year in Victoria and South Australia

Victorian Premier Daniel Andrews. Picture: AFP

MINING & ENERGY

The Australian Business Review

The Australian

12:00AM January 30, 2018

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SAMANTHA HUTCHINSON, Victorian State Political Writer, Melbourne

MICHAEL O'NEIL, SA Bureau Chief, Adelaide

Average wholesale energy prices in Victoria and South Australia have more than doubled since this time last year, as experts warn that blackouts and supply issues are...
Final report reveals the causes of South Australia’s statewide blackout

A FINAL report into South Australia’s statewide blackout has been released today that highlights what authorities need to do to keep the lights on.

AUSTRALIA’S electricity system needs to adapt to the increasing use of renewable energy, a final report into South Australia’s statewide blackout has found.

The Australian Energy Market Operator has highlighted valuable lessons and challenges identified following the blackout of September 28, which cut power to 850,000 customers in South Australia.

While the Federal Government was keen to blame the state’s reliance on renewable energy for the blackout, AEMO said two tornadoes were the likely cause of five electrical faults that happened before the network went down.

The state was left without electricity for hours when the tornadoes brought down three rings or transmission lines in the state’s north.

But AEMO’s investigations found nine of the state’s 13 wind farms did switch off because they were unable to withstand voltage disturbances.

This ultimately caused faults in the system that caused the blackout because it overloaded the Heywood interconnector, which provides SA with electricity from Victoria.
Electricity Market Reform – ESB, NEG

- At the moment there is only an Energy Market but not a Capacity Market.
- Hazelwood (1.4GW in Victoria) has already closed.
- AGL (Australian Gas and Light) set to close Liddell Coal fired power plant (2GW). There’s pressure for AGL to sell to Alinta¹.
- Investor uncertainty for new generation.

ESB: Energy Security Board
NEG: National Energy Guarantee

How could SMRs compare?

<table>
<thead>
<tr>
<th></th>
<th>NuScale SMR (3 x 50 MWe)</th>
<th>Macarthur Wind Farm (140 turbines)</th>
<th>Ivanpah Concentrated Thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capex (AUD)</td>
<td>$1 billion</td>
<td>$1 billion</td>
<td>$2.9 billion</td>
</tr>
<tr>
<td>TWh / annum</td>
<td>1.183</td>
<td>1.288</td>
<td>1.078</td>
</tr>
<tr>
<td>Land area</td>
<td>18</td>
<td>5,500</td>
<td>1,420</td>
</tr>
<tr>
<td>Dispatchable?</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Capacity factor</td>
<td>90%</td>
<td>35%</td>
<td>20.5%</td>
</tr>
<tr>
<td>Lifespan</td>
<td>40-60</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>
SMR flexible siting

Suitable sites NSW from a network view

Large-scale nuclear

Small-scale nuclear

Source: Professor John Fletcher (UNSW)
1. NFC Royal Commission in South Australia (2016).
2. Ongoing work by the Department of Industries on the National Radioactive Waste Management Facility (NRWMF).
3. Recent ascension to Gen IV forum.
4. Australia remains a major exporter of uranium
5. Robust operations of the OPAL (20 MW\textsubscript{th}) research reactor
South Aust. NFC RC Recommendations

1. Pursue removal at the federal level of existing prohibitions on nuclear power generation to allow it to contribute to a low-carbon electricity system, if required;

2. Promote and collaborate on the development of a comprehensive national energy policy that enables all technologies, including nuclear, to contribute to a reliable, low-carbon electricity network at the lowest possible system cost;

3. Collaborate with the Australian Government to commission expert monitoring and reporting on the commercialization of new nuclear reactor designs that may offer economic value for nuclear power generation;

4. Pursue the opportunity to establish used nuclear fuel and intermediate level waste storage and disposal facilities in South Australia.

Thanks for listening.

Questions?