Tabled by Mr Barry Murphy, 18 November 2019

Reliable and Affordable Electric Power Generation

why Australia should develop a balanced mix of generation options

Introduction

Australia is facing difficult choices with its future electric power supply options on the National Electricity Market (NEM). After years of relying on coal, gas, and hydro generation, it must now deal with rising concerns about cost, availability, and reliability of differing types of replacement generation as ageing power plants are shut down and commitments to reduce emissions take hold.

There is no shortage of review by various government agencies or public comment on these issues. Regrettably, much of this discussion does not have the benefit of understanding the complexities of power system engineering, despite oft-repeated claims that such reviews are "technology neutral" or "technology agnostic". The fact is that technology matters, and poorly informed choices on the NEM can lead to expensive mistakes that could bedevil our prosperity as a nation for many years to come.

To help better understanding, this Paper has been prepared as a public service by a small group of professional engineers and scientists experienced in various aspects of electricity and distribution (see P.2). It is about sensible technology choices for the NEM to work as a cost-efficient reliable system.

Recommendations

1. Wind-up subsidies for intermittent power generation

Apart from being expensive to taxpayers and of questionable merit in meeting lower emissions, subsidies for intermittent power generation on the NEM reward investment without regard to the generator's ability to meet minute by minute changes in customer demand. This has distorted recent investment decisions, resulting in a suboptimal mix of generation technologies.

2. Add a capacity market component to the National Electricity Market

The current NEM is an energy-only market, which does not give clear signals when more or replacement dispatchable generation investment is needed. This weakness has been a key factor in the current absence of new dispatchable investment, i.e. power which can be delivered at the time it is needed by customers.

3. Remove the ban on nuclear power

This ban is the result of a political deal done 20 years ago. It has no scientific merit, and is now an obstacle to much-needed decisions for the longer-term future. It prohibits by law the development of emissions-free, reliable, affordable nuclear power for Australia. The removal of the ban would allow more competition between various technologies to supply our future electricity needs.

Method

A computerised model known as the Power System Generation Mix Model has been constructed to incorporate the fundamental elements of the interstate NEM grid system covering Qld., NSW, ACT, Vic., Tas. and SA.

The model enables the comparative economics of a wide range of alternative electricity supply scenarios, comprising selected mixes of proven technologies, to be tested under actual recorded load conditions. Technologies in the model's data base include solar PV, wind, open-cycle gas turbine (OCGT), combined-cycle gas turbine (CCGT), black coal, brown coal, hydro, nuclear, pumped storage, and some battery storage. The selected mix can be run to evaluate the total system delivered cost of electricity under any known NEM load pattern in the most efficient and reliable way possible using sophisticated algorithms.

From this, key outputs can be determined e.g. **total System Levelised Cost of Energy (SLCOE)**, which is defined as --

"...the average cost of producing electric energy from the combination of generation technologies chosen for the system over its entire lifetime, discounted back to today at 6% per annum."

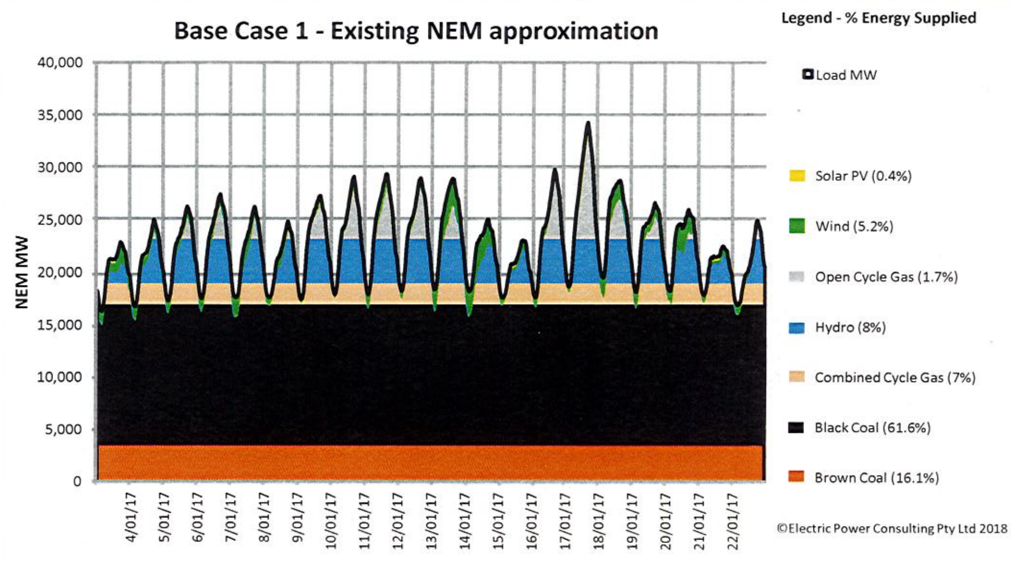
Note that this includes the additional transmission cost, where needed above existing capacity levels, to delivery electricity to customers. The resultant carbon intensity is also shown.

Any number of Cases can be run, but not all will be feasible. For this Paper, **six Cases** relevant to Australia's current situation are shown in adjoining Pages. The model uses 17,520 measures of total electric customer power demand (load) plus actual wind and solar PV available to the NEM for every half-hour over the whole of 2017. From this, a sample 20 day period is used in the Cases to illustrate how that representative load can be met . The model then allows the Cases to explore a wide range of generation mix scenarios that would be used to meet that demand at lowest system cost.

This provides the output data shown under each Case, plus relevant comment where necessary. Rooftop solar PV, above existing levels, has been included with utility scale PV. All costs are in current A$.

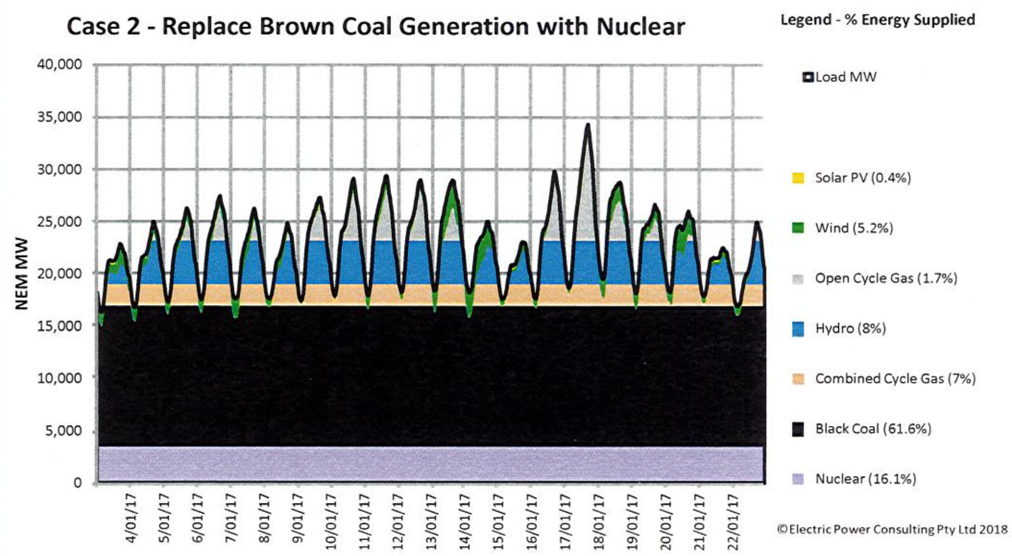
Contributors to this Paper, together with all key technology performance data, costs, and other relevant information are listed in the Power System Generation Mix Model website https://epc.com.au/?p=113 . A copy of the Paper in PDF form is also available on the website.

Base Case 1 - Existing NEM approximation



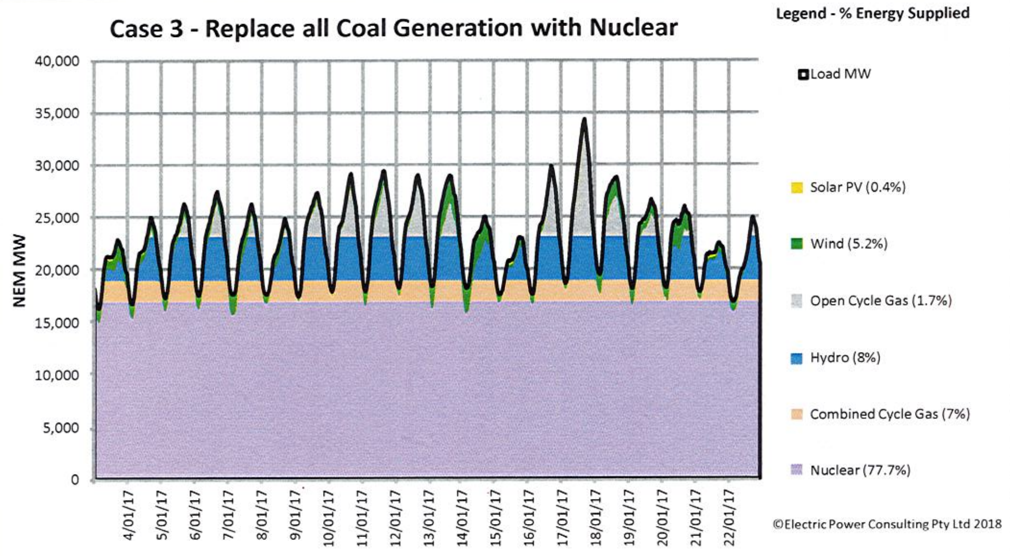
- **SLCOE = 68.87 $ / MWh**
- **Base transmission & distribution cost = 142.25 $ / MWh**
- **Total delivered cost = 211.12 $ / MWh**
- **Generation mix approximating the existing NEM, allowing comparison with other options.**

Case 2 - Replace Brown Coal Generation with Nuclear



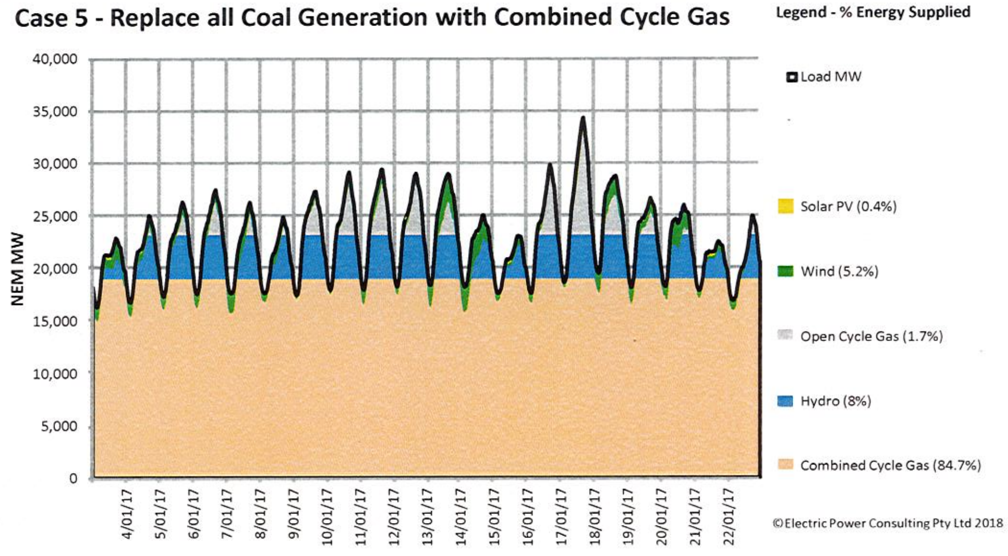
- **SLCOE = 72.48 $ / MWh**
- **Base transmission & distribution cost = 142.25 $ / MWh**
- **Total delivered cost = 214.73 $ / MWh**
- **Modest inclusion of nuclear, significant reduction in emissions, modest cost increase.**

Case 3 - Replace all Coal Generation with Nuclear



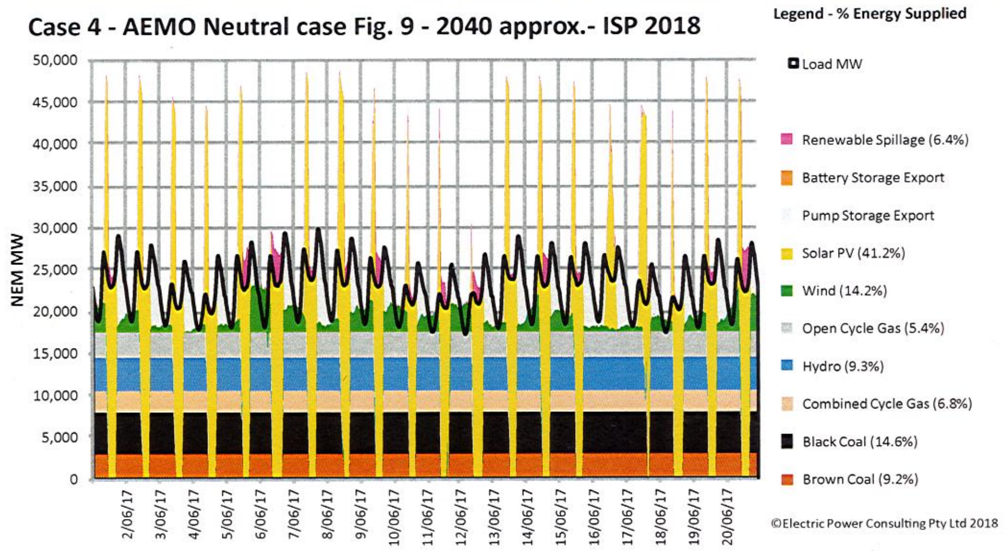
- SLCOE = 90.23 $ / MWh
- Base transmission & distribution cost = 142.25 $ / MWh
- Total delivered cost = 232.48 $ / MWh
- All coal replaced by nuclear, near elimination of emissions, tolerably higher cost.

Case 5 - Replace all Coal Generation with Combined Cycle Gas



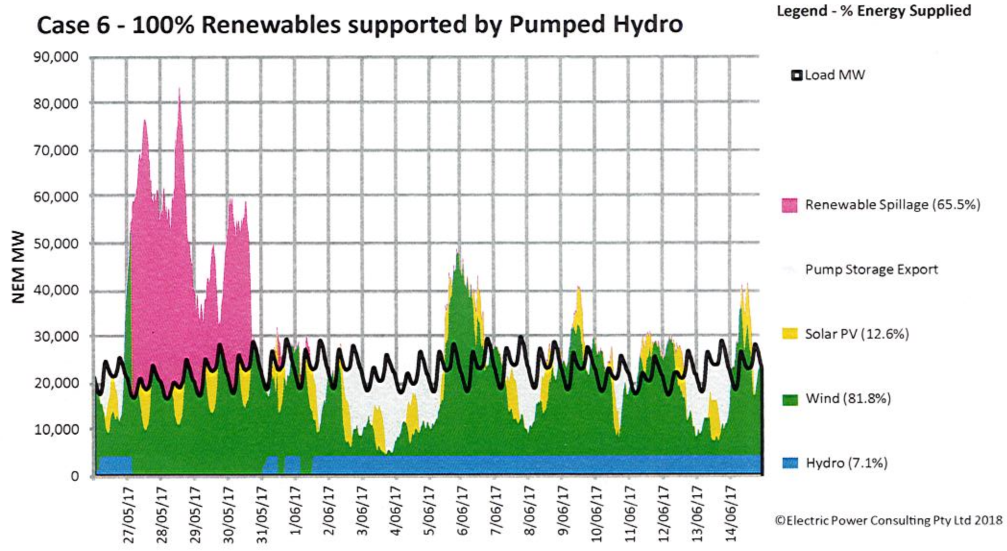
- SLCOE = 96.72 $ / MWh
- Base transmission & distribution cost = 142.25 $ / MWh
- Total delivered cost = 238.97 $ / MWh
- All coal replaced by CCGT, much reduced emissions, higher cost by comparison with others.

Case 4 - AEMO Neutral case Fig. 9 - 2040 approx.- ISP 2018

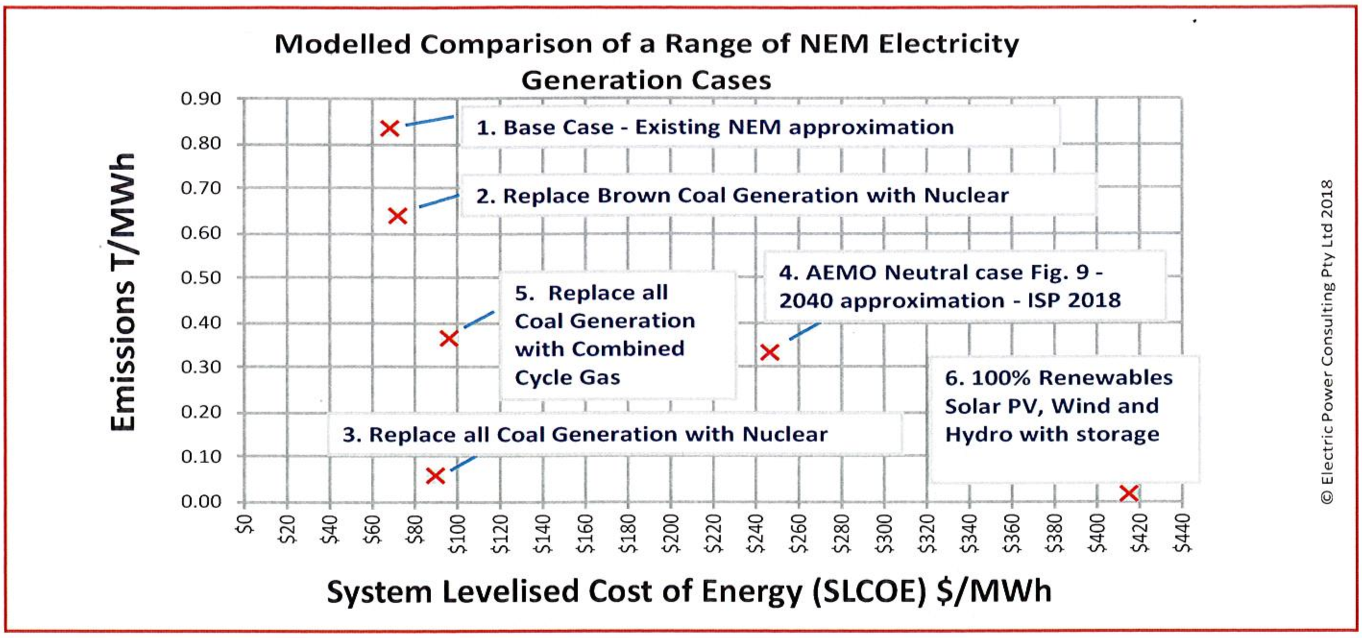


- SLCOE = 247.44 $ / MWh
- Base transmission & distribution cost = 142.25 $ / MWh
- Total delivered cost = 389.69 $ / MWh
- AEMO 2040 'neutral' projection, appears to make baseload unworkable, significantly higher cost.

Case 6 - 100% Renewables supported by Pumped Hydro



- SLCOE = 415.50 $ / MWh
- Base transmission & distribution cost = 142.25 $ / MWh
- Total delivered cost = 557.75 $ / MWh
- 100% renewables, probably unworkable as a system, near-zero emissions, much higher cost.



Summary

This modelling shows that Base Case 1 (existing NEM approximation) has an average base load of 18,368 MW of constant electricity demand. This load plus daily peaks must be reliably supplied at all times. At present this is done using a system of 78% coal, plus combined-cycle gas turbine (CCGT), open-cycle gas turbine (OCGT), wind, solar PV, and hydro. Some battery storage is available for the provision of ancillary and other services as needed.

Case 2 shows the effect of introducing 3,000 MW of nuclear power capacity into the Case 1 mix to replace brown coal. As expected, this adds + $ 3.61 / MWh (0.36 cents / kWh) to the System Levelised Cost of Energy (SLCOE), making a total of $ 72.48 / MWh while reducing emissions by around 23%.

Case 3 shows the effect of replacing all coal in Case 1 with nuclear power. Emissions fall by some 93%, with SLCOE increasing to $ 90.23 / MWh.

Case 4 shows the effect of the combination of generation technologies projected by the Australian Energy Market Operator (AEMO) to 2040, as shown in its Integrated System Plan (ISP) of July 2018.

Case 5 shows the effect of replacing all coal in Case 1 with CCGT. Note that this shows an increase in SLCOE of + $ 6.49 / MWh versus Case 3 above, plus a substantial increase in emissions.

Case 6 shows a 100% renewable mix comprising solar PV, wind and hydro with support from pumped storage and some battery storage. Because of low capacity factors, solar PV and wind require a combined total of 110,000 MW of capacity. There is also a need for 30,000 MW of pumped storage capacity for 3 days. To this must be added high-cost additional transmission to get the power to points of high consumption where it is needed, making a total SLCOE of $ 415.50 / MWh.

These Cases demonstrate the general trends in trying to contain costs while at the same time maintaining reliability and reducing emissions. There are no easy answers, but careful analysis based on the generation mix as a whole is essential.

Conclusion

Current electricity supply issues are best thought of in two time frames : --

- **short-term (0 -- 10 years)**
- **longer-term (0 -- 30 years).**

In the short term the proposed National Energy Guarantee (NEG) should be supported, but the expansion of intermittent generation and storage as projected by AEMO should be examined for practicability and cost. The NEG would also benefit from including a capacity market component to provide clear signals for investment in dispatchable generation when needed.

For the longer-term, the existing ban on nuclear power development for Australia must be lifted. Given our role as an important supplier of uranium to the world, current national policy in this area appears confused. A bipartisan agreement in the Australian Parliament to lift this ban is now a matter of urgency, so that proper examination of this option can be undertaken.

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