SUBMISSION TO AEMO RE INTEGRATED SYSTEM PLAN CONSULTATION

Denis Cooke & Associates Pty Limited

PO Box 4741 North Rocks NSW 2151

www.decoa.com.au

28 February 2018

Disclaimer:

The information in this submission does not constitute professional advice and Denis Cooke & Associates Pty Ltd. does not warrant the accuracy, content, completeness or suitability of the information in this document for any purpose. Accordingly Denis Cooke & Associates Pty Ltd will not be liable for any claims or damages whatsoever resulting from the use or reliance on any information provided in this submission. © Denis Cooke & Associates Pty Ltd 2018.

Submission to AEMO re the Integrated System Plan Consultation

Introduction

I make this submission in my capacity as a consultant with 30 years' experience in the energy industry advising a range of clients from small businesses to multinational corporations on their energy use and energy efficiency. I also make this submission in my professional capacity as an electrical power engineer.

Background

The AEMO Integrated System Plan Consultation document has been produced to address recommendation 5.1 of the Finkel review, viz., "*By mid-2018, the Australian Energy Market Operator, supported by transmission network service providers and relevant stakeholders, should develop an integrated grid plan to facilitate the efficient development and connection of renewable energy zones across the National Electricity Market (NEM*)."

The document sets out the processes to be adopted by AEMO to comply with this recommendation.

Focus of this Submission

Whilst there are many questions in the consultation document about which I could offer a professional opinion, I've chosen to focus this discussion around selected questions listed under Section 1.3 *Scenarios and Sensitivities* and in particular:

1) What is the best way to achieve the policy objectives of affordable, reliable, secure power and meeting emissions targets?
   a) -
   b) Could large-scale renewable generation in targeted zones provide an efficient solution for future power system development, and what storage and transmission investment would be needed to support such an outcome?
   c) What is the optimal balance between a more interconnected NEM, which can reduce the need for local reserves and take advantage of regional diversity, thereby more efficiently sharing resources and services between regions, and a

more regionally independent NEM with each region self-sufficient in system security and reliability?

d) To what extent could aggregated load shifting and price responsive load management, made available through investment into distributed energy resources (DER), reduce the need for large-scale generation and transmission development to replace the existing generation fleet as it reaches end of life, while maintaining power system reliability and security?

2) -

Comments on Question 1 b)

From the consultation document, AEMO is required to investigate and model the availability of renewable energy (mostly wind and solar PV) in designated renewable energy zones (REZs) situated across all States in the NEM and connecting same to the NEM via a series of new transmission lines. The general thrust of the planning process appears to presuppose that large-scale renewable power generation would be useful as a source for providing reliable power across the NEM but with a caveat that detailed economic modelling is to precede the development.

Justification for this broad approach appears to rest in the two paragraphs immediately preceding Figure 6 on page 22 as follows:

This figure shows the diversity of wind generation between regions, and how negatively correlated wind and solar generation are across each region. This demonstrates the potential benefits of co-locating wind and solar generation projects, taking rooftop PV growth into account, to deliver a smoother generation profile on average.

By showing the average daily profile of wind generation, this chart does not consider the periods where there is very low (wind and solar) generation, how long these periods can last, and whether such periods coincide between regions. This is a vital consideration when determining the level of dispatchable capability required to support wind generation and, in the case of energy storage, the optimal energy capacity required.

The first paragraph suggests that there are benefits in co-locating these types of renewable energy resources. The second paragraph does provide a warning about the suitability of these types of resources in terms of the capacity that they would provide but does not discuss the matter any further. The reader is left with the impression that co-locating renewable energy projects in REZs in the manner generally as outlined would be a useful way to meet the objectives of Q1, i.e., meeting (Australia's) emissions targets.

My submission is that to proceed on this basis without a complete analysis of all the underlying engineering considerations is fraught with the certainty that the resulting system would at times not provide any firm power generation capacity as well as reducing significantly the reliability and stability of the national grid.

Renewable energy is intermittent and the average load as suggested by Figure 6 and in the first paragraph above is meaningless in the context of delivering the actual demand required to the grid. Sound electrical engineering principles simply are that the delivered power must equal the actual instantaneous demand across the grid for every cycle and millisecond. Mismatch over more than a few cycles will cause frequency changes and instability that if not properly corrected could rapidly result in grid collapse.

An illustration of this fact is the recent paper produced by Bill Nixey from IES about the operation of the SA power system on 9 February 2018. The paper illustrates how the wind energy can fall off quickly, and in this instance on 8th February, to almost zero. See Figure 1 extracted from the paper.

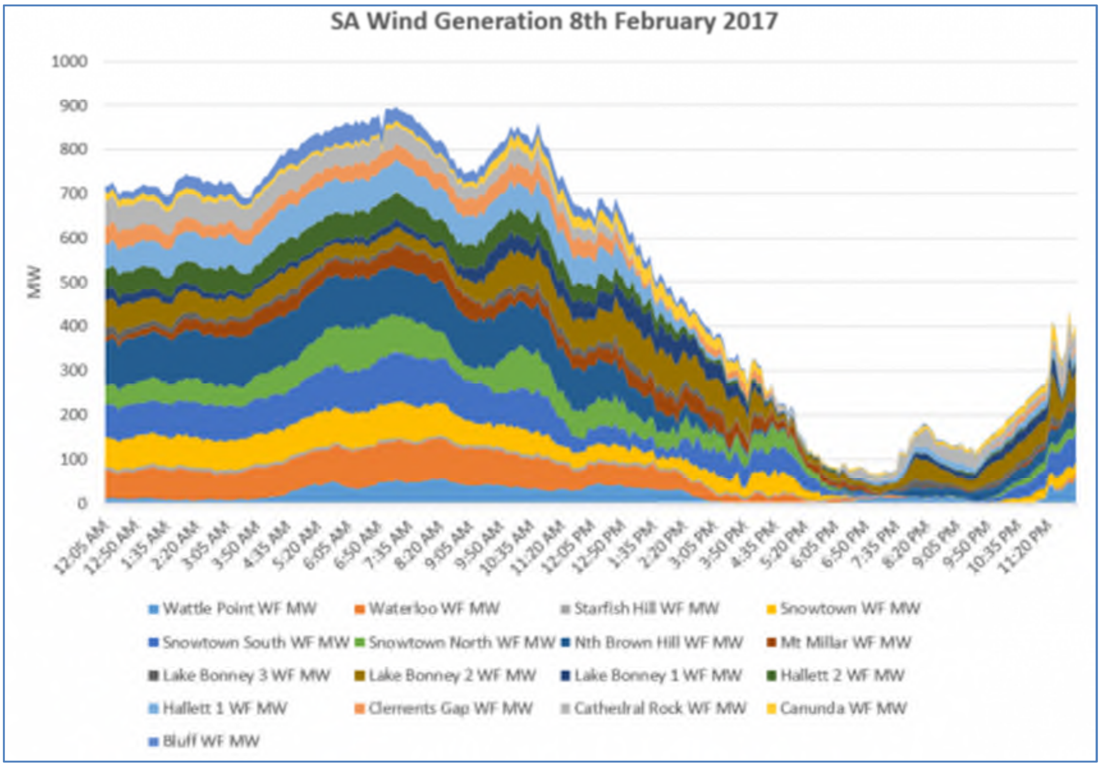


Figure 1:

Figure 1 shows the particular circumstances in SA when there was insufficient wind energy coupled with the power imports over the Heywood and Murray Link interconnectors and insufficient local dispatchable capacity resulting in an inability for the available supply to meet local demand. Load shedding of 100MW resulted with the disconnection of 40,000 customers. It is assessed that during this process, AEMO would have dispatched all SA gas generators and possibly the new diesel generators out of merit order to ensure that there was enough inertia in the system to prevent a system loss as occurred in September 2016. At the same time power flow over the interconnectors would be constrained to ensure that the inertia that was available from the local dispatchable generators was sufficient to cater for a credible contingency event, i.e. to ensure that the system would ride through a credible contingency event with sufficient time for the primary and secondary frequency control ancillary services (FCAS) to correct the initial rate of change of frequency (ROCOF) and restore the system to equilibrium. In the incident described on 8th February, system stability was restored through load shedding. Subsequently when the local demand fell below or equal to the available generation, power was restored to the disconnected customers.

See Appendix A for the full article.

Also, other data shows that there are significant times across the NEM where the combined output from solar PV and wind energy is effectively zero or negative as the existing wind farms draw a parasitic load from the network.

Thus a key consideration in evaluating the usefulness or otherwise of widely dispersed renewable energy sources across the NEM would be their impact on the overall system. Detailed consideration should be given to system operation, particularly the initial ROCOF which is expressed in the swing equation: $ROCOF = \frac{df}{dt} = \frac{\Delta P}{2H}\ x\ fo$ where ΔP = MW lost, H = system inertia (MW-sec) and fo = initial frequency. It is clear that a system with low system inertia will have a faster ROCOF in turn possibly requiring yet faster FCAS.

Whilst AEMO commissioned a report from GE to examine options in providing faster FCAS, the identified options have the risk that they at best provide a short term measure to provide sufficient time for conventional FCAS to operate.

The inescapable fact is that the initial ROCOF is determined by the characteristics of the contingent event at the time, viz, the nature of all connected loads, generators, the disturbance level and the inertia on the system at that instant. As the inherent inertia in the system is significantly reduced by the impact of asynchronous renewable energy generation and the retirement of old base load synchronous thermal power stations, the initial ROCOF on the system will be ever greater in turn requiring faster FCAS to maintain stability. If not properly managed, this problem could at some stage become uncontrollable.

In addition, high levels of intermittent asynchronous renewable power generation produce a weak system with low fault levels. The question then arises about whether the protection relays and systems will continue to operate correctly and safely as designed. These matters need to be addressed in the overall consideration of the impact of the proposed REZs on the total system.

Summary

Wind energy and solar PV power generation is intermittent and for significant times of the year provides zero or near power to the grid. It has no useful inertia for FCAS services and even if some was available it could not be relied upon when needed. High levels of asynchronous renewable power generation result in a weak system with low fault levels and possible consequential incorrect operation or failure of protection systems. Wind energy and solar PV generation, with a relatively short lifetime, have all been installed on the basis of significant subsidies at the expense of end users. The claim that this type of power generation provides one of the cheapest forms of electricity available fails to consider these characteristics but can readily be tested by abandoning any subsidies.

Cost and project evaluation of connecting this type of power generation to the grid should include at least all of the following electrical engineering design issues:

- Impact on the inertia in the system – e.g. what is the overall effect on the inertia time constant of the system from say reducing it to about 3 seconds[1]? (What is the actual time constant in the REZs imposed system that has to be managed?)
- Frequency control.
- Protection operation.
- Transmission line losses – overall losses of transmitting intermittent energy sources over significant distances? An often heard complaint about the existing grid is that the transmission lines are "gold plated", i.e., oversized to meet a demand for only a short time of the year if at all. Whether this criticism is justified or not, would not the construction of the transmission lines to REZs be worse?
- Transmission line utilisation – asynchronous renewable energy generators have poor capacity factors.
- Real and reactive power flows – given that most renewable generators are set to generate at unity power factor, what would this mean for the reactive power generation / absorption in the system?
- Where will the power grid be in five years then twenty to thirty years' time?

Also what is AEMO's fall-back position if in the aftermath of a particularly record cold northern Winter that the emerging scientific stories predicting a period of global cooling as a result of the current and a continued low solar activity turn out to be correct?

Denis Cooke, BSc(Eng), MEngSc, MBA, FIEAus, NER, MAICD

Managing Director

Denis Cooke & Associates Pty Ltd

Phone 02 9871 6641

Mobile 0411030936

denis@decoa.com.au

28 February 2018

[1] E.g., see Thoughts on the UK Energy Storage Market: The Problem of System Inertia

Appendix A: The South Australian Power Outage in Three Simple Charts

A paper by Bill Nixey, Lead Consultant at IES Advisory

(Kind permission from Bill to allow its inclusion here).

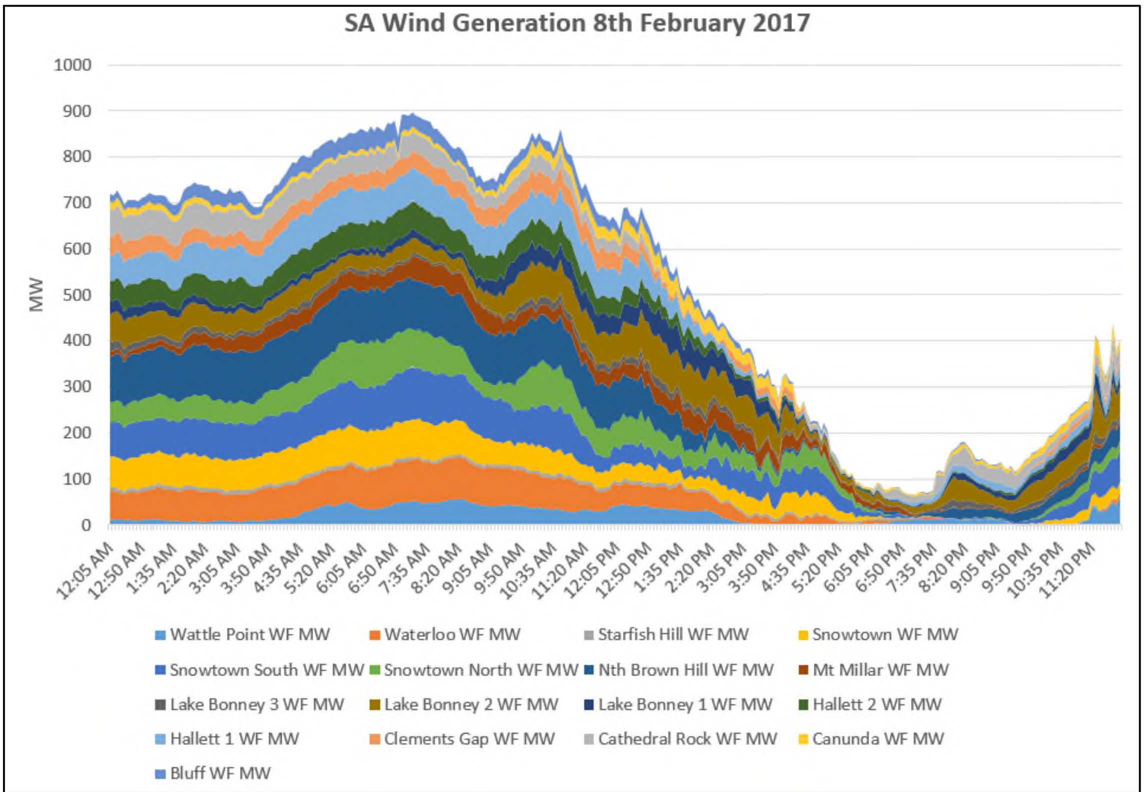
LINK

[url http://iesys.com/news/the-south-australian-power-outage-in-three-simple-charts/]

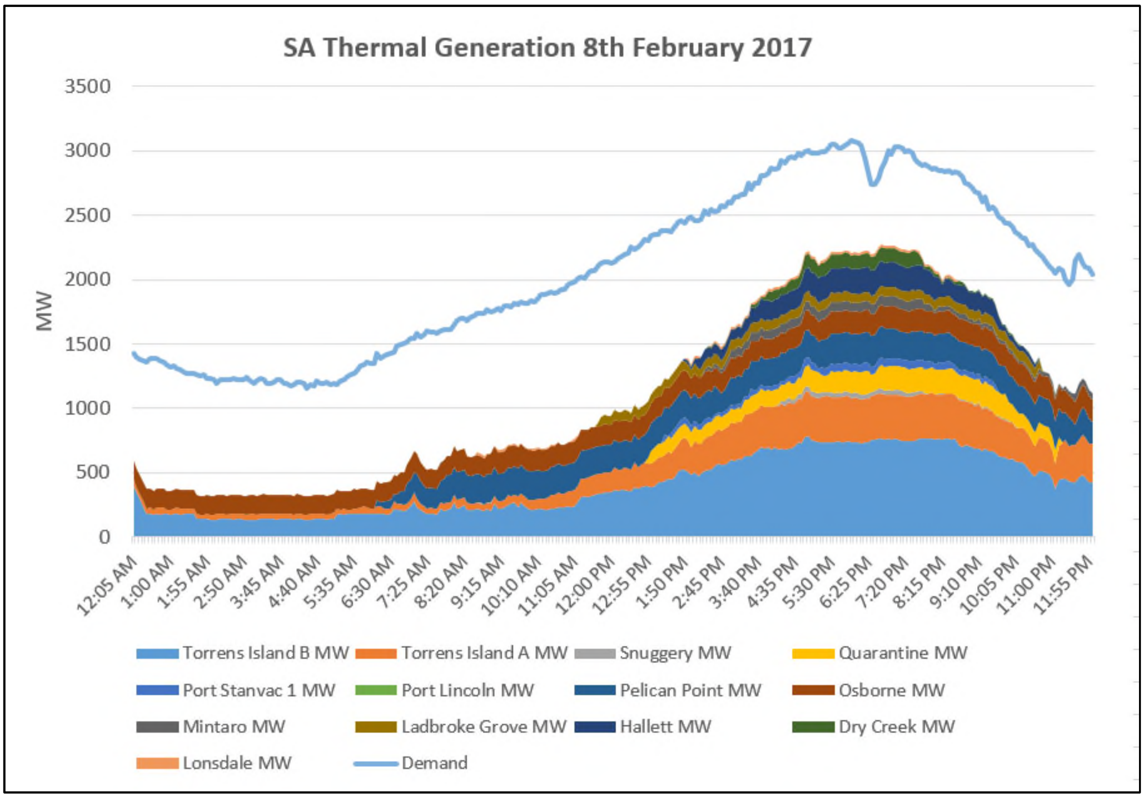
40,000 South Australian electricity customers were without power yesterday and the market operator was forced to shed load.

Here's three simple charts explaining what happened:

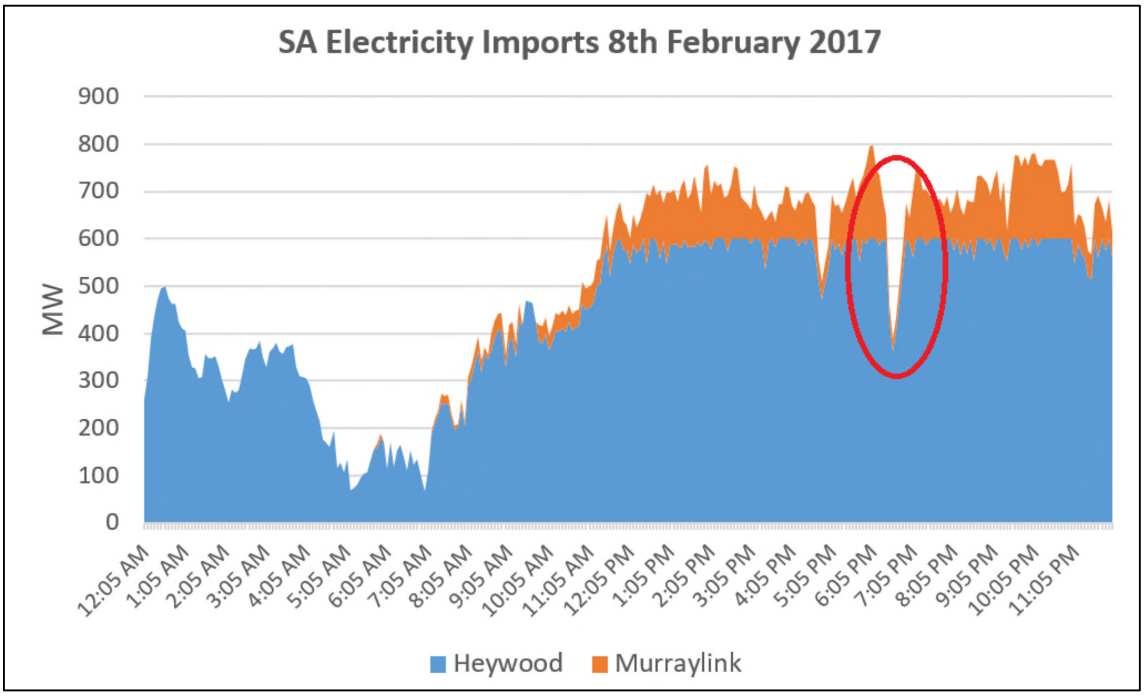
1. *Wind generation dropped during the day:*



2. *South Australian electricity demand increased during the day. The thermal generators (gas and diesel) responded by increasing output:*



2. *But the power imports from Victoria weren't enough to meet the looming shortfall. Interconnector capacity limits contributed to load shedding of 100 MW:*



The data used in these charts is supplied by NEOexpress, a product of Intelligent Energy Systems.

This article was originally published on Bill Nixey LinkedIn: bit.ly/2kHFaV6