EESA Submission to AEMO on the

"Integrated System Plan Consultation"

www.eesa.org.au

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Executive Summary

On 17 December 2017, AEMO published an "Integrated System Plan Consultation for the National Electricity Market" and sought submissions that "are not limited to the specific consultation questions contained in each chapter".

By analysing five minute samples of the AEMO SCADA generator data over a one year period, this report clearly demonstrates that it is not possible to gain a clear understanding of the firm capacity of wind and solar output using average values of fluctuating generation. Neither will any modelling based on average values be of any practical use.

Any meaningful analysis of generator requirements must be based on minimum and maximum diversified output, firm capacit**ies** and not average outputs or nameplate ratings.

About the Electric Energy Society of Australia

The Electric Energy Society of Australia (EESA) is a not-for-profit learned technical society established to advance interest in the field of electric energy. Membership is open to individuals and organisations interested in the purpose and objectives of the society, with our key objectives being to provide a continuous professional development program to members and educate stakeholders on key electricity related issues.

The EESA has a history dating back to 1924 and has been a key part of the Australian Electricity Industry for almost 100 years.

The Electric Energy Society of Australia (EESA) is pleased to contribute to the Integrated System Plan Consultation. As a learned society made up of professionals within the Electricity Supply Industry the EESA has a significant contribution to make to Australia’s Energy Future.

The EESA is an independent incorporated body and a technical society of Engineers Australia. The views expressed in this report are from expert members of the EESA and not necessary those of the EESA or Engineers Australia.

The detailed analysis contained in this report has been prepared by Electric Power Consulting Pty Ltd (EPC) for the EESA. EPC is a company associated with the current National President of the EESA.

Overview of AEMO Integrated System Plan Consultation Report

The AEMO "Integrated System Plan Consultation" report sets out a strategy to analyse future transmission and NEM developments in order to meet the needs of electricity customers. The report identifies the clear goal of delivering continued reliability and security at the lowest long-term cost for consumers, while meeting emissions reduction targets. These are goals that the EESA supports.

As with all planning, the AEMO planning strategy will involve many assumptions. The AEMO report goes into considerable detail on how the power system modelling will go into ever greater detail to capture wind and solar PV diversity across dispersed geographic areas. The emphasis appears to be toward adding ever more complexity to the modelling to produce more detailed and accurate results. The risk within the AEMO approach is that a massive modelling effort will push some of the fundamentals so deep into the analysis that they will be overshadowed by second order considerations.

The nature of wind and solar PV diversity across the NEM is of vital importance and it is for this reason this submission has focused on this issue. AEMO needs to deal with diversity differently to give confidence to the industry that it will be dealt with adequately in the modelling. As such, the EESA recommends that AEMO's initial work should focus on understanding the characteristics of all generator types, especially the diversity characteristics of wind and solar PV across the states. By establishing the diversity characteristics at a macro NEM level this can be used to vastly reduce the amount of detailed modelling required and simplify the analysis to yield better results. This is an approach the AEMO is encouraged to adopt.

If implemented well, there are customer benefits to be gained by optimised transmission development and establishment of the proposed "renewable energy zones" where these are based on clear demonstrated economic benefits.

Fundamental Diversity Characteristics of Wind and Solar PV

Diversity in power systems is of the utmost importance especially with respect to customer loads and intermittent generation sources like wind and solar PV. The AEMO report correctly stresses the importance of diversity of wind and solar PV across the state regions of the NEM. Figure 1 is an extract of figure 6 from the AEMO report. This figure is presented as an average daily profile for wind and an indicative daily profile for solar PV generation.

Readers could easily interpret from the AEMO graph that wind generation alone can provide a near base load generation capacity when output is diversified across the NEM and that solar PV can provide regular consistent output on a daily basis This interpretation is not supported by detailed analysis of actual wind farm output data across the NEM.

Figure 6 Average daily profile of wind farm output per region (NEM time)

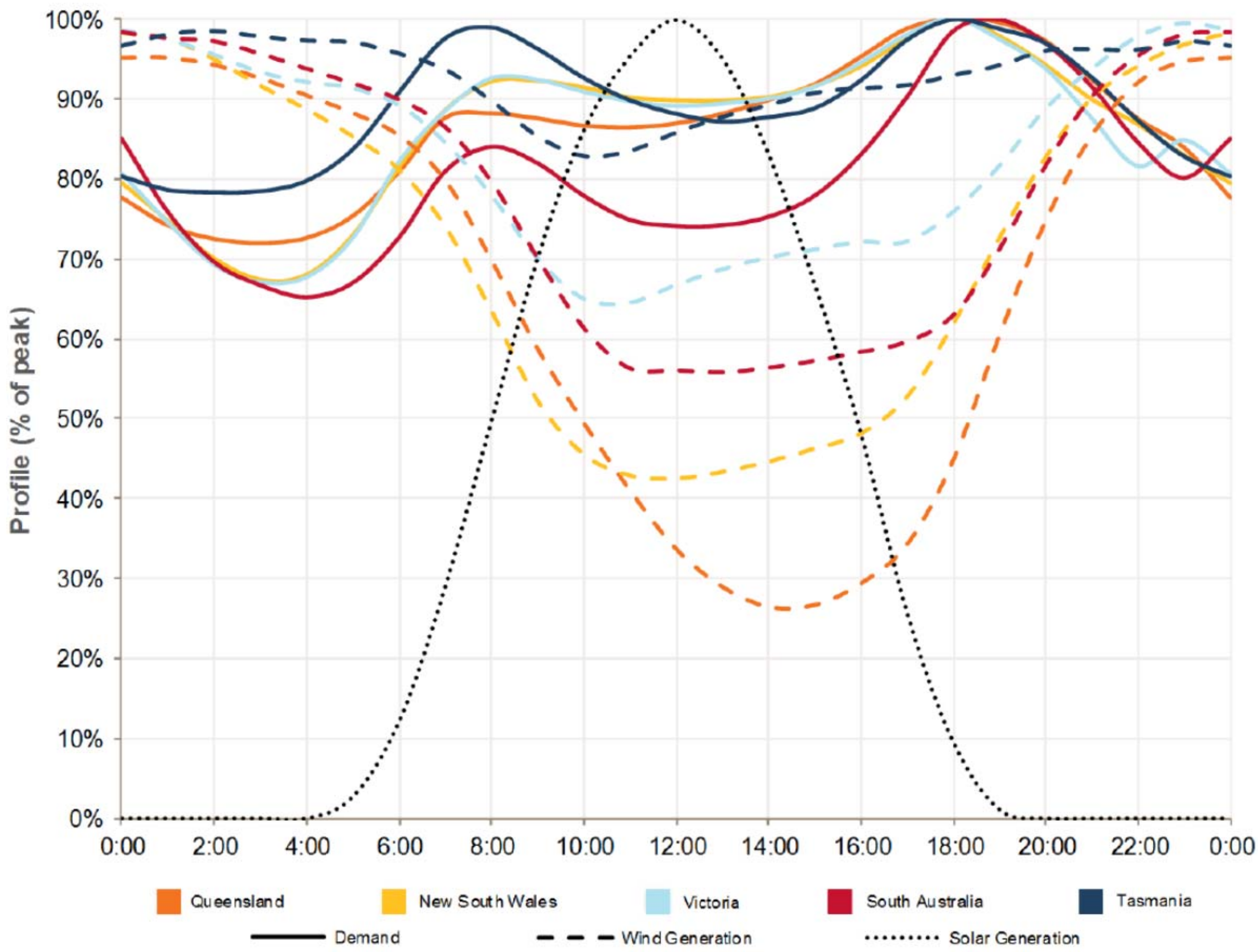

Figure 1 - Extract of figure 6 from the AEMO Report

A more thorough analysis of diversified wind and solar PV generation has been completed by Electric Power Consulting Pty Ltd and the results are shown in figures 2 to 7.

Figure 2 shows the NEM wide output from all windfarms contributing data to AEMO SCADA data (generally windfarms >50MW). This graph is based on 5 minute samples over a 1 year period commencing 3/1/2017. This data represents the diversified windfarm output across the NEM and clearly shows the intermittent nature of the output not evident in the AEMO graph.

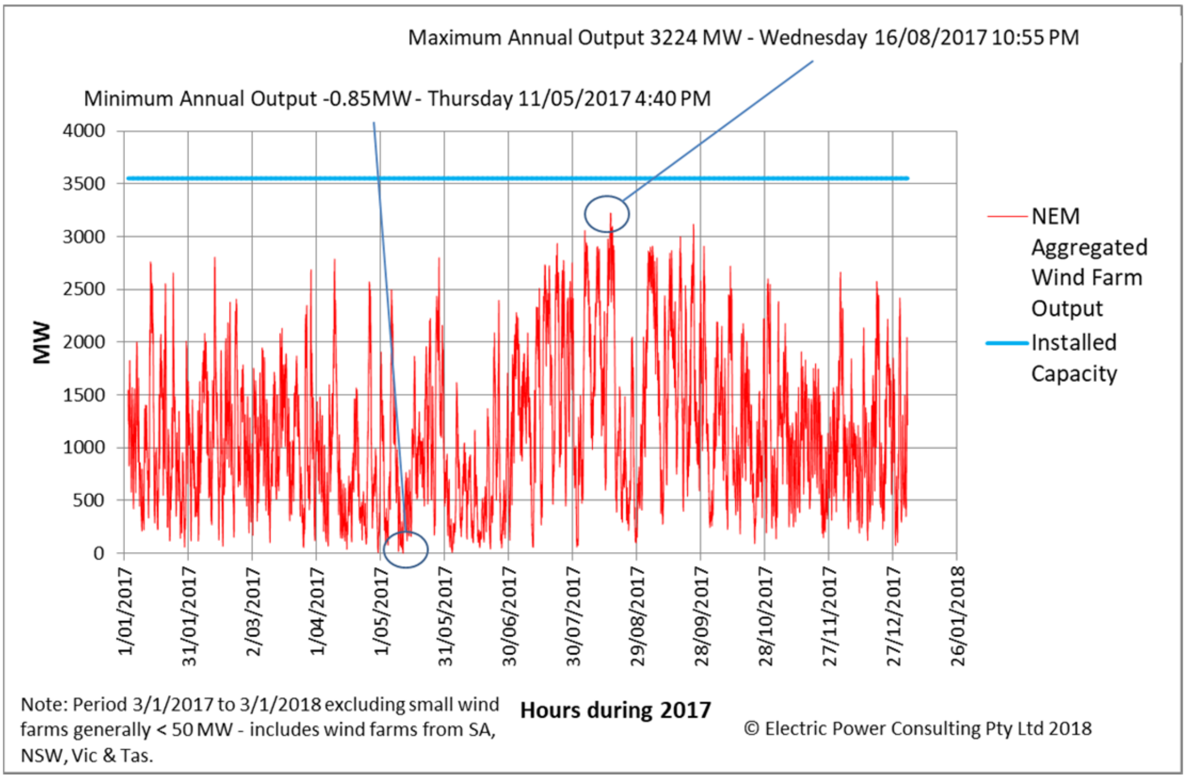

Figure 2 - NEM Wide Aggregated Wind Farm Output 2017

Figure 3 shows a sample of 14 consecutive days of aggregated diversified NEM wide wind output. This graph further illustrates the intermittent nature of the wind farm output.

Figure 4 shows time of day NEM wide aggregated windfarm output in a form similar to the AEMO graph. The difference between the EPC Figure 4 graph (Based on AEMO SCADA data analysed by EPC) and the AEMO graph is that is shows variability of output by plotting installed MW capacity, maximum outputs, minimum outputs in addition to the ±1 standard deviation spread about the mean. The average generation output curve (red) is similar in shape to the AEMO curve with a minimum at about 10:00am.

Of particular interest is the capacity factor of about 30-33%. This means that the average wind farm output is about 30-33% of the rated installed capacity. Where dedicated transmission lines are being considered it means the lines and grid connections must be sized to meet the peak outputs, resulting in ongoing average utilisation of the system to be low. Good quality modelling and simulations would pick up these issues in the planning process.

Figure 5 shows the output duration curve for the aggregation of all wind farms in comparison with a single wind farm. The effects of diversity between wind farms is very evident. The single windfarm shown is a South Australian windfarm with a rating of near 100MW. This windfarm has been chosen at random and is likely to have output characteristics similar to many other windfarms.

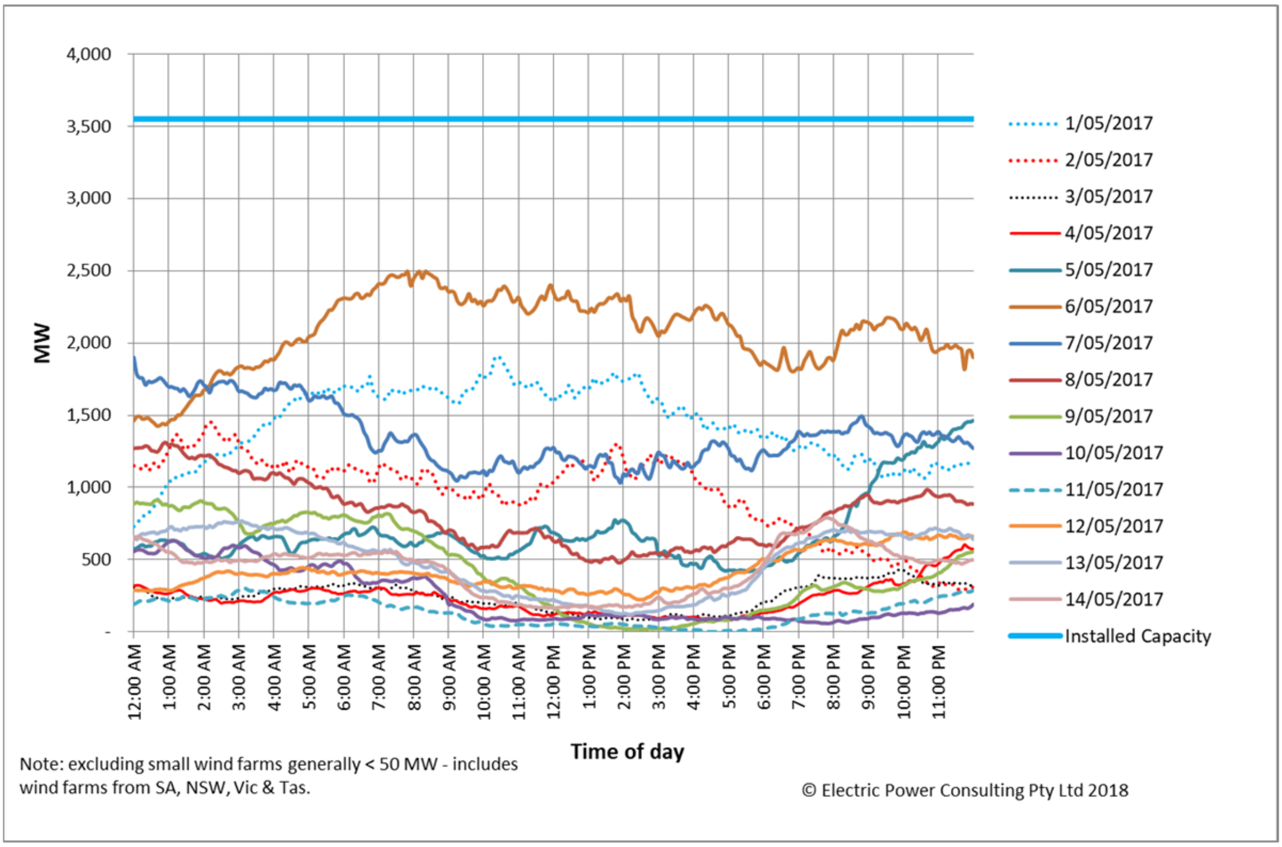

Figure 3 - NEM Wide Aggregated Wind Farm Output 1 to 14 May 2017

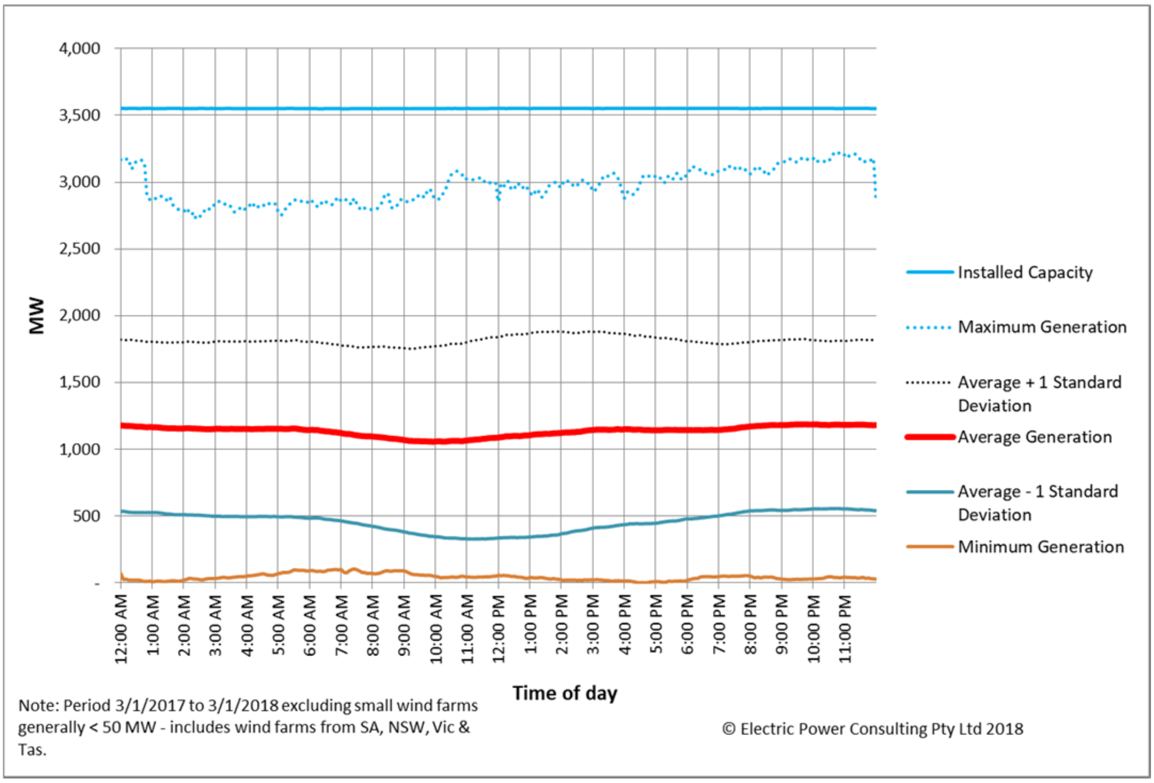

Figure 4 - NEM Wide Aggregated Wind Farm by Time of Day

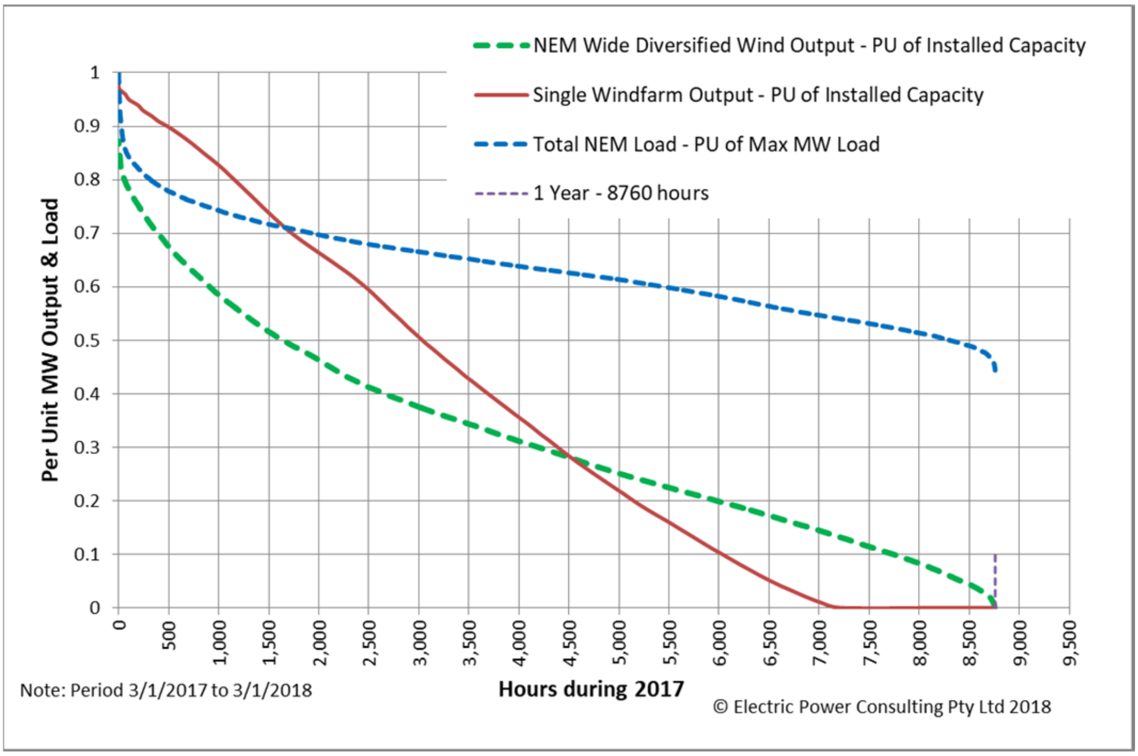

Figure 5 - NEM Load & NEM Wide Aggregated Wind Farm Output Duration Curve

The single windfarm had over 3000 hours of no MW output during 2017 and reaches a peak output of approximately 0.99 PU or about 99MW. By comparison the NEM wide aggregated output also has zero or negative output but for a lesser time of two 5 minute intervals during the year. The inescapable conclusion from this analysis is that even if the NEM had a perfectly strong transmission system capable of unconstrained power movement from any part of the NEM to the other, there would be periods where the NEM wind farm output would not be able to supply the auxiliary loads of the wind farms not producing (i.e. negative net output) and make no contribution to the dispatched capacity of the NEM.

Figure 5 also shows the load duration for the total NEM load. It shows that the minimum NEM load is above 50% of the maximum load. Comparison of the duration curves shows that while diversity across NEM regions improves the characteristics of the wind output, there still exists a very major mismatch between the load and the wind generation that cannot be addressed without very large quantities of storage.

Figure 6 shows a sample of 14 consecutive days of aggregated diversified output of the five solar PV farms in the NSW/ACT region. This graph illustrates the intermittent nature of the solar farm output.

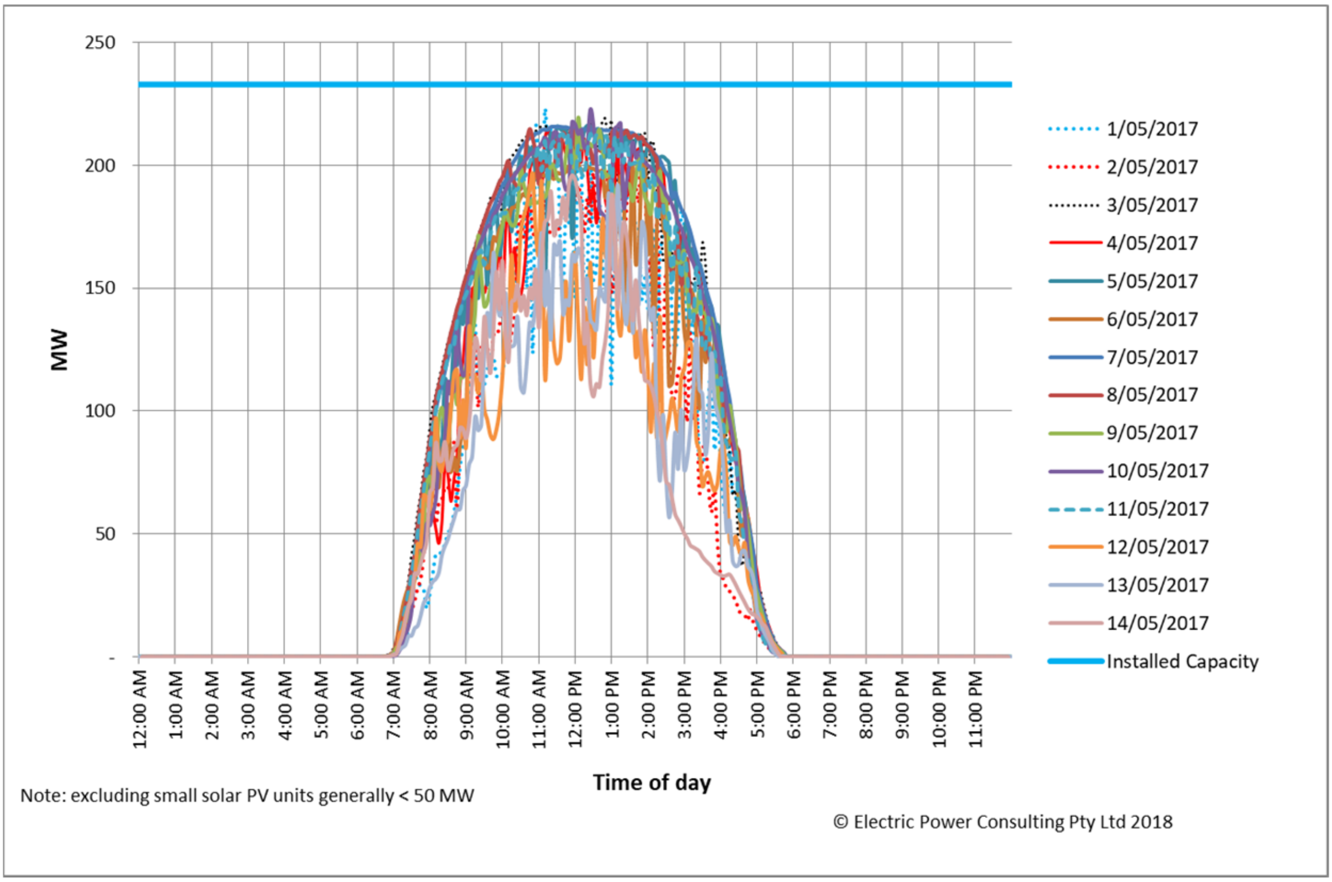

Figure 6 - NSW/ACT Aggregated Wind Farms 1 to 14 May 2017

Figure 7 shows time of day NSW/ACT wide aggregated solar PV farm output in a similar form to the AEMO report. The difference between Figure 7 (Based on AEMO SCADA data analysed by EPC) and the AEMO Figure 1 is that it shows variability of output by plotting installed MW capacity, maximum outputs, minimum outputs in addition to the ±1 standard deviation band. The average generation output curve (red) is similar in shape to the AEMO curve.

The minimum generation curve demonstrates that the intermittency of solar PV means that little reliance can be placed on the output to provide any firm capacity across the NEM at the very time it could be most needed to meet peak demands. Diversity assists in providing some degree of predictability of output but only to a limited extent.

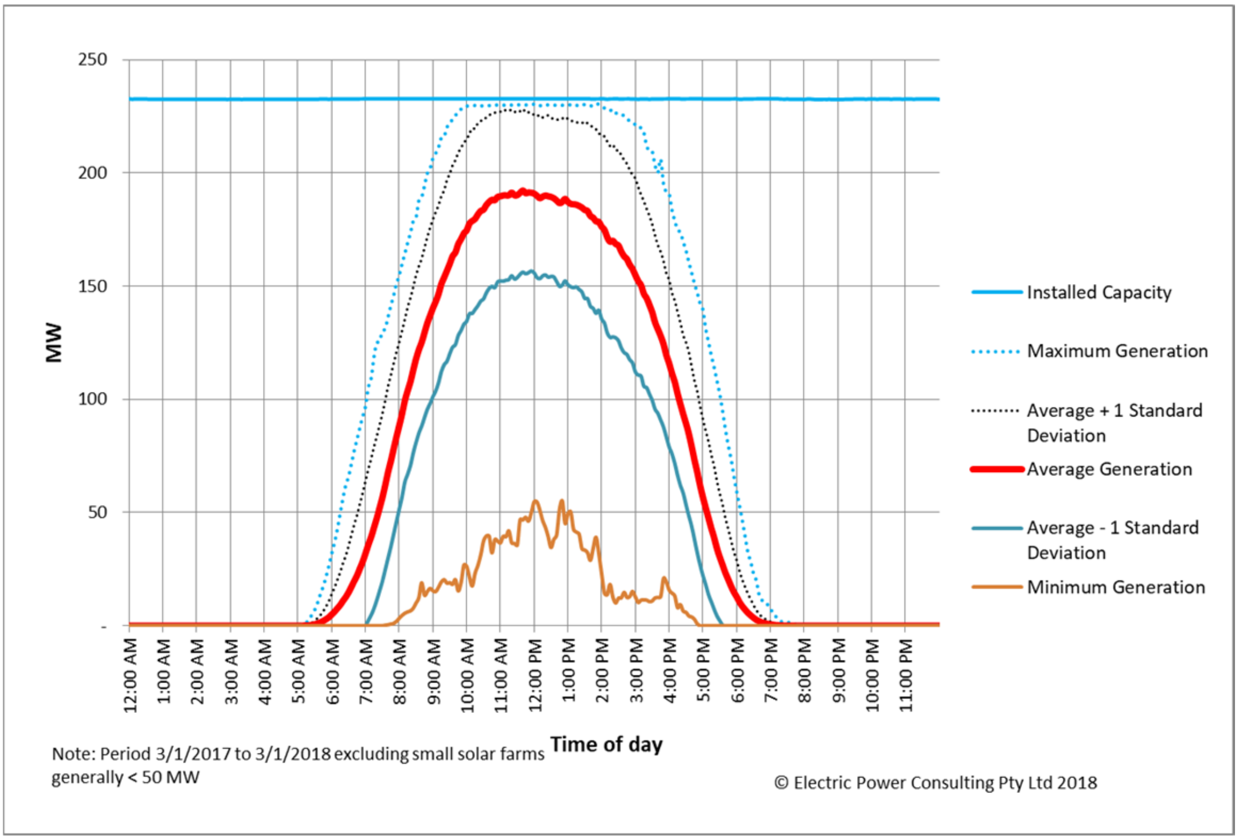

Figure 7 - NSW/ACT Aggregated Solar PV Farm Output by Time of Day

Conclusions on Wind/Solar PV Diversity & Storage across the NEM

The data and analysis provided shows that while diversity across the NEM improves the availability of wind and solar PV generation (without storage), the level of resulting firm MW dispatchable capacity that can be relied upon when needed is minimal, zero or in some cases negative.

The lack of dispatchable MW capacity that is created by wind and solar PV projects needs to be taken into account when undertaking feasibility studies for investments in new transmission capacity designed to allow their connection to the grid or their output to be transported interstate.

This does not mean that the wind and solar PV output has no value. It means that the inherent value is related to energy only and needs to be associated with storage (e.g. pumped hydro or batteries) or in displacing fuel in dispatchable fossil fuel and hydro generators. This dispatchable generation is essential in meeting the capacity needs of customers on a 24/7 basis.

Dispatchable MW Capacity

Figure 8 shows an extract of figure 8 from the AEMO report. The inference from this graph and other statements in the AEMO report is that the wind generation can provide a level of firm dispatchable generation. However, the previous analysis indicates that the level of contribution to peak demand from wind and solar PV that can be totally relied upon when needed is minimal or zero.

Figure 8 Registered capacity and maximum demand in South Australia, 2008-17

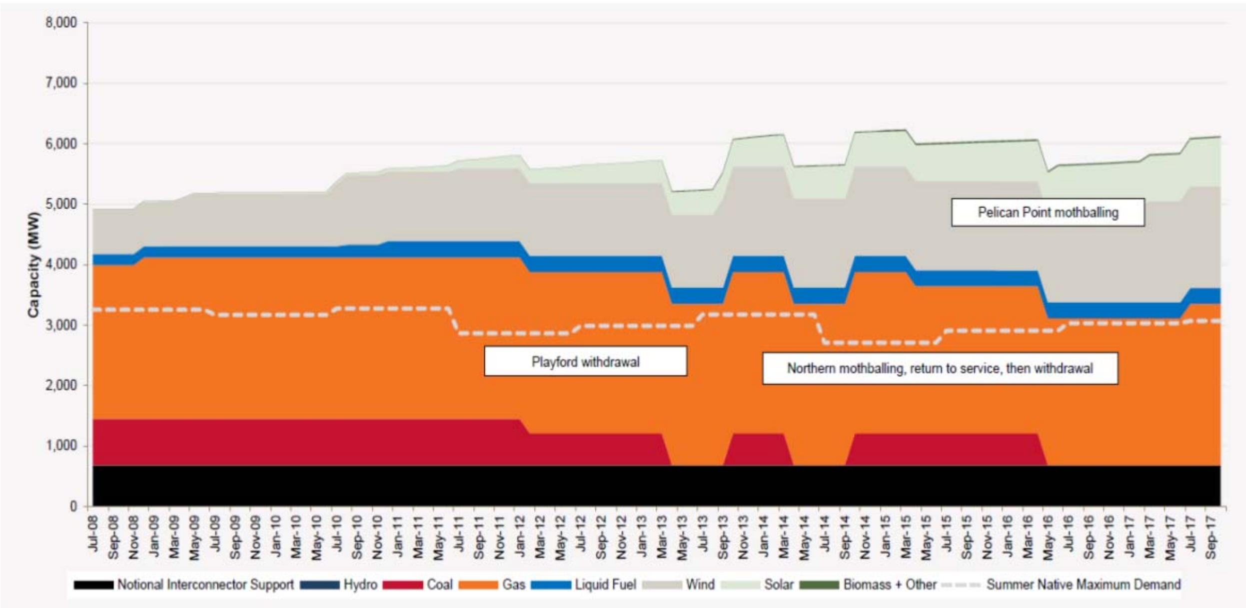

Figure 8 - Extract of figure 8 from the AEMO Report

Readers of the AEMO report could easily misinterpret from this graph that South Australia has excess capacity to meet its peak demand needs. On this graph it may have been better to label the Y axis “Installed Capacity MW” or “Nameplate Capacity MW” so as not to confuse the output with “Dispatchable Capacity MW”. The alternative would be to have graphs that contain dispatchable generation only.

Return on Investment Test – Transmission

The Australia Energy Regulator (AER) has developed a Return on Investment Test (RIT-T) for major transmission works. The aim of this test is to ensure that only the best and most economic transmission projects are approved. The purpose of the test is detailed below:

The purpose of the RIT-T, as set out at clause 5.6.5B(b) of the Electricity Rules, is to identify the credible option that maximises the present value of net economic benefit to all those who produce, consume and transport electricity in the market (the preferred option). For the avoidance of doubt, a preferred option may, in the relevant circumstances, have a negative net economic benefit (that is, a net economic cost) where the identified need is for reliability corrective action.

The RIT-T test is vitally important to managing transmission electricity costs for customers. This is particularly important in the light of very high electricity price increases that most electricity customers have experienced over the last few years.

In undertaking planning for the Renewable Energy Zones as set out in the AEMO report the EESA urges AEMO to:

1. Be very mindful of the RIT-T and make sure proposals have a positive net present value and are the best projects on offer.

2. Be diligent and fair when assessing costs and benefits of the various options.

3. Examine all options that may be feasible including alternate options that do not involve Renewable Energy Zones.

The Costs of Energy and Capacity

The AEMO Report in section 2.2.2 states that "continued innovation in wind and PV generation technologies in particular means they are now recognised as the cheapest form of new bulk energy generation globally". With wind and solar PV having fuel at zero marginal cost this statement is essentially correct but only in terms of MWh energy. In terms of dispatchable MW capacity, wind and solar will be amongst the most expensive form of generation globally.

Providing firm dispatchable MW capacity from wind and solar PV using diversity across the NEM has been shown to be problematic. To provide any significant firm MW capacity, wind and solar PV needs to be linked to large scale storage by way of pumped hydro, batteries or other storage technologies. The total costs of converting wind and solar PV output into dispatchable are very high and need to be considered by AEMO in their planning processes.

The AEMO report references the cost of wind and solar PV energy without reference to the related cost of providing firm dispatchable capacity which is required to assess the costs and benefits of all generation options and thereby achieve the best long term outcome for customers.

Demand Side Management & Electric Motor Vehicles

The AEMO Integrated System Plan needs to evaluate demand management, demand side response, energy efficiency and changing consumption patterns especially the likely disruption from the impact of the pending electric vehicles.

Lower Cost Alternative Options to the Renewable Energy Zones Need to be Considered

In the process of system planning, the use of renewable energy zones will clearly be the main focus of options to be considered. These zones would require large investments in transmission extensions and augmentations. Under our regulatory regime these investments would lead to ongoing increases in network service charges that would be borne by electricity customers for forty years or more. These charges will relate to providing a return on capital, depreciation and maintenance costs of new transmission lines.

Due to these high ongoing network costs, alternative schemes that better utilise existing transmission assets and provide equivalent or better outcomes need to be explored as part of the planning processes. These alternative schemes should include measures that improve the efficiency of the existing fossil fuel fleet. One such option is to progressively replace selected old high CO_2 producing generators such as brown coal plants with new highly efficient combined cycle gas generation. Proposals of this type have the potential to save on network charges while simultaneously providing dispatchable capacity and lower CO_2 emissions.

Other options such as geothermal, nuclear and gas firming capacity for renewables may well be economic and viable in the future and need to be considered in the planning process.

Whatever options are finally considered to be the most desirable, it is important that they pass the RIT-T to ensure that customers receive the best value for money from their future electricity dollars.

Conclusions & Summary

AEMO have a very difficult task ahead in developing the Integrated System Plan for the NEM. In respect to the consultation paper the following summary of key points are provided:

1. This report has provided AEMO with detailed analysis on wind and solar PV diversity that could be used to greatly simplify and improve the modelling process.

2. AEMO is urged to use the information provided by the EESA on wind and solar PV diversity to simplify their planning task.

3. There are some limited benefits accruing from wind and solar PV diversity across the NEM during times of high output.

4. At times of low wind and solar PV generation output, aggregate outputs still fall at times to negative, zero or near zero values despite the effects of diversity across the NEM.

5. Without large scale storage, wind and solar PV cannot be relied upon to provide any significant dispatchable MW capacity to meet peak customer demands.

6. While wind and solar PV have very low marginal costs for energy, they have very high costs for dispatchable MW capacity. Both costs need to be considered together in the planning process.

7. In the planning process, AEMO need to carefully apply the principles contained in the RIT-T to the proposed "Renewable Energy Zones" as well a full range of other options including demand response and the introduction of more energy efficient fossil fuel generation.

8. The use of average values of statistical variables in modelling of the non-dispatchable generation assets is unlikely to add any technical or commercial value.

Like more Information?

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