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Mr John Pierce
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Dear Mr Pierce

Integration of Energy Storage: Regulatory Implications

The Australian Energy Market Operator (AEMO) welcomes the opportunity to contribute to the Australian Energy Market Commission's (AEMC) review of the regulatory frameworks in the context of storage technologies.

AEMO agrees with the AEMC that the National Electricity Rules (NER) would benefit from clarification on the definition of *generating unit* so that there is no uncertainty in its technology neutrality. This would enable storage systems (and other non-conventional technologies) to be registered as *Generators* and participate in the market.

While this would be a useful step forward for utility scale storage, it will not deal with the expected growth in small scale storage. It is imperative that the industry and our regulatory frameworks learn from the experience of rooftop photovoltaics (PV) to ensure that system-wide effects are taken into consideration when assessing connection processes and performance standards. This is particularly the case with storage systems as they have the potential to be operated in concert depending on the associated commercial arrangements. This in turn can aggregate to have a material impact on the transmission network.

From a system operation perspective, having visibility of storage devices connected at the distribution level is critical, as is the ability to explore what technical standards are most applicable.

Please find AEMO's submission attached. Please feel free to contact Alison Demaria on (03) 9609 8937 if you would like to discuss this submission.

Yours sincerely

David Swift
Executive General Manager, Corporate Development

Attachments: AEMO Submission

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1. Integration of energy storage: Regulatory Implications

AEMO's submission concentrates on three key areas raised in the discussion paper (paper):

- Registration and connection of storage;
- Network businesses integrating storage; and
- Ownership and control.

1.1. Registration of storage systems

1.1.1. Definition of generator

The paper expresses the AEMC's view that the regulatory frameworks can, at present, accommodate storage systems. This is accompanied by the premise that any system that exports electricity to the grid is a generating system (Section 5.1.2).

However, the AEMC has recognised that there may be merit in clarifying the Rules with respect to the definition of a 'generator'. AEMO is supportive of the need for clarity as the current regulatory framework creates legal uncertainty.

As referenced in Appendix A of the paper, AEMO has been examining the regulatory arrangements applicable to registration under the National Electricity Rules (NER) of a storage system. It is AEMO's view that the NER does not give AEMO the flexibility to permit developers of non-conventional forms of energy generation to participate in the National Electricity Market (NEM).

The provisions of the NER require that a person seeking registration as a *Generator* owns, operates or controls one or more *generating units* used to produce electricity. A *generating unit* is defined as[1]:

> The actual generator of electricity and all the related equipment essential to its functioning as a single entity.

This creates uncertainty for the classification of battery storage as a 'generator'. In the context of this definition a generator is commonly defined as plant that converts mechanical energy to electricity energy for use in an external circuit. This excludes solid state devices such as solar and battery storage systems, and is true for both small generators registering as aggregators and utility scale systems.

If AEMO were to receive an application for a large scale storage system at present, based on the Rules, it could be registered as a load but legal uncertainty would surround its registration as a Generator. From an operational perspective, registering storage as a Generator would mandate more comprehensive performance standards that would assist in managing the power system.

In the paper, the AEMC has referred to the current level of photovoltaic (PV) generation in the NEM as an example of where the NER has been accommodating solid-state generating units. These installations, however, have been almost exclusively at the distribution level, and the owners/operators are exempt from the requirement to apply for registration as their plant was below the 5 MW threshold for registration. Furthermore, from an operational perspective, AEMO has only been able to track the uptake of PV, and hence its aggregate impact at the transmission level, thanks to the need for proponents to register with the Clean Energy Regulator (CER). This is discussed in greater detail in

[1] See Chapter 10 of NER

section 1.1.4. The availability of data for embedded PV is therefore not indicative of the difficulties which could arise in obtaining information on embedded storage systems.

The experience with solar generators to date also does not reflect the potential challenges of registering proponents of utility scale storage systems in the NER. In accordance with the AEMC's desire for more clarity in the Rules, AEMO is considering submitting a Rule Change Proposal that seeks to alter the definition of *generating unit* to allow it to be both technology-neutral and process-neutral.

The Rule Change would seek to avoid the need to define what a 'generator' is, and remove any ambiguity in what can be classified as a *generating unit*. It would also accommodate all uses of storage systems, from standalone installations to those coupled with other generating systems such as wind.

Importantly, this Rule Change would seek to enable all proponents of all forms of generation (which will be defined to mean any method of producing electricity) to participate as *Generators* in the NEM, consistent with the technology neutrality of the market (clause 3.1.4 of the NER).

1.1.2. Registration of aggregated storage

The uncertainty around the ability to register storage systems as a *Generator* within the NER also extends to the ability to register small generation as aggregators.

Further to this, AEMO is concerned that section 2.2.2 of the paper could unintentionally be misleading, with the statement 'there are no exceptions of the types or sizes of small generating units that may be included in a small generator aggregator's portfolio'. By definition, a *small generating unit* has two conditions:

- Its nameplate rating must be less than 30 MW; and
- Its owner/controller/operator is exempted from the requirement to register as a *Generator* by AEMO.

Further, a *small generating unit* relies on the definition of *generating unit* to work, which leads one to the same definitional issue over the meaning of 'generator'.

Registration as a barrier

The AEMC also asked whether the requirement to register for participation in the NEM is a barrier to *Small Generation Aggregators*. For *Small Generation Aggregators*, the registration fee for 2015-16 is $10,000, which is half of that charged to Generators.[2] This fee forms part of AEMO's participant fee structure which has been determined in accordance with clause 2.11 of the NER. Once registered, proponents are also obliged to comply with the terms of their registration.

AEMO is happy to discuss this matter further with the AEMC as it further considers whether these costs may be a barrier for the aggregation of small-scale storage systems.

Ancillary services

At present, small generator aggregators cannot provide market ancillary services as clause 2.2.6 of the NER specifies that only *Market Generators* may apply to classify their *generating units* as *ancillary service generating units*. The AEMC asks whether the provision of frequency control ancillary services (FCAS) should be extended to other parties, and thus allow small generator aggregators the opportunity to offer FCAS. AEMO suggests there is no reason why small generator aggregators should be precluded from offering FCAS if they meet the technical specifications required by the NER and AEMO.

[2] http://www.aemo.com.au/About-the-Industry/Registration/~/media/Files/About%20the%20industry/Registration/2015/FINAL_1516_Electricity_Revenue_Requirement_and_Fee_Schedule.ashx

The NER also sets out the requirements for market ancillary service offers, including that bids must be specified in whole MW (clause 3.8.7A(i)). This places a threshold of 1 MW on the minimum quantity of FCAS that can be provided. This may pose a barrier for some small generator aggregators. If this requirement were to change, then the AEMC would need to take into account the following:

- AEMO's systems were designed to comply with the existing Rule, and cannot currently accommodate bids that are non-integer MW. A thorough analysis of the cost of changing the system has not as yet been performed, but it would likely be a significant cost; and
- If bids less than 1 MW were considered, the associated cost in systems changes, registration, dispatch, verification of service provision and settlement would need to be weighed up against the benefits of the service, while noting the practical consideration that the impact on the power system of individual sub 1 MW services would likely not be readily measurable.

The AEMC also asked what technical or data requirements would need to be addressed to allow proponents to register for ancillary services. The requirements for ancillary services set out in Rules seek to be technology neutral and should be able to be applied to other sources. The requirements may, however, be burdensome for smaller storage installations and may require specialised solutions. AEMO would be prepared to contribute to discussions on this matter, or to work with storage proponents on the technical requirements and specifications for services.

1.1.3. Registration of wholesale/transmission connected storage

AEMO agrees with the AEMC that there is no need for further *Registered Participant* categories.

Whether a *Generator* wishes to be registered as *Market* or *Non-Market* is a matter for the applicant. AEMO will assess applications based on the intended use of the storage system, and determine the appropriate category in accordance with the NER. Whether they should be *Scheduled Generators* or *Non-Scheduled Generators*, however, is a question that should be determined in relation to the technical and operational needs of AEMO as the system operator. AEMO also has the ability to apply conditions to generators seeking registration as non-scheduled.

The paper envisages arrangements where storage providers could register as both a customer and a generator.[3] This approach is feasible, however it will be necessary to ensure that there is clarity with respect to a number of practical issues.

For instance, it will be important to consider how they operate in the market, and what information AEMO needs. Current hydro generation with pumped storage bid both load and generation into the dispatch, allowing AEMO to effectively schedule the central dispatch process. For large scale storage systems, it is anticipated that AEMO would require both the generation and load components to be scheduled so as to manage the dispatch process. This could be coordinated with the single meter that is also configured for settlement purposes.

It may also be necessary to clarify the network charging arrangements that apply to storage systems, given that load pays transmission use of service changes while generation does not. AEMO notes that under NER 2.2.4(d), market generators purchase electricity from the spot market and do not pay network charges. These arrangements reflect the characteristics of pumped storage, where the pumping itself is a relatively small component of the plant operations. This is not true for battery storage with the load comparable to the generation. There are a range of factors to consider when developing efficient network charging arrangements. While there is scope for cross subsidies if different types of loads are treated differently, there is also scope for battery storage to provide network benefits that a typical load cannot offer.

In section 5.1.2, the paper puts forward the argument that as electricity is the battery's fuel source it cannot be treated as an auxiliary load. By itself, this statement is true, however, it may potentially give

[3] AEMC, *Integration of Energy Storage – Regulatory Implications, Discussion Paper 9 October 2015,* pg 75. [Available at: http://www.aemc.gov.au/Major-Pages/Integration-of-storage/Documents/Integration-of-Storage-Discussion-Paper.aspx]

rise to further inconsistencies in how existing generators are registered. An example is coal generators where the process of obtaining their fuel from onsite mines is deemed an auxiliary load.

A further relevant issue is the technical standards that apply to different classes of registered participant. If a unit is subject to more than one set of technical standards, the higher standard should apply.

AEMO recommends a clear, consistent approach be taken early for storage systems. It will be important to work through these issues now before any future uptake, as early registrations will send signals as to whether new projects should be treated the same as other loads. We welcome the opportunity to work with the AEMC to develop appropriate registration arrangements.

Finally, the paper considers whether the 5 MW threshold for exemption from registration is still appropriate for the proponents of storage systems combined with a generating system. As discussed, this threshold was determined by AEMO's predecessor at the start of the market and is detailed in the NEM Generator Registration Guide.[4] In the changing environment, there may be value in reconsidering the exemption threshold. Given the growth in embedded generation and storage, it would also be important to consider the regime that applies to units that fall below the threshold but which, by the number of units deployed, can have an even greater impact on the power system.

1.1.4. Connection

AEMO welcomes the AEMC's consideration of connection processes and standards for storage systems at both the distribution and transmission levels. In the case of the former, AEMO intends to limit its comments to those aspects that intersect with its operational functions.

The experience with rooftop PV has demonstrated that while small, individual systems have no impact on the overall operation of the power system, as penetration increases, the aggregated behaviour of the individual systems can materially impact the transmission network. It might be appropriate to consider whether there are practical means of regulating the technical characteristics of facilities in aggregate rather than focussing on a facility's local interaction with the network as standalone.

This may mean that additional technical standards are required, or that AEMO would require a broader reach for Access Standards. At present, AEMO has not undertaken sufficient analysis to determine what connection processes for distribution connected storage systems would be required to maintain power system security should there be mass uptake of the technology. Examples of issues that need to be investigated include rapid changes of state of the systems in aggregate, and the displacement of scheduled generation which leads to difficulties controlling the transmission network flows within limits. Information about the behaviour of small-scale storage systems in aggregate is another issue that is discussed in section 1.3.2.

For the connection of storage systems at the transmission level, the processes and requirements embedded in Chapter 5 of the NER are suitable, and should be treated in a manner consistent with any other generating (or load) technology. However, similar to above, AEMO has not yet assessed whether the current Access Standards will be adequate for the mass uptake of utility scale storage systems, or where particular challenges might arise. The negotiation of performance standards, data, modelling and commissioning requirements are based on actual performance of the plant. AEMO considers that these current standards are appropriate for the present, but further work is required on the future implications of storage and other technologies for system security.

AEMO is in the process of establishing a Power Systems Issues Technical Advisory Group, to begin the process of identifying technical challenges in relation to emerging technologies in general. Further information is expected to be emerging from that work by mid-2016.

[4] http://www.aemo.com.au/About-the-Industry/Registration/~/media/Files/Other/Registration%202014/Registration%20Final/ATTACHMENT_2%20_Participant_Categories_in_the_NEM_2.ashx

The AEMC's questions regarding appropriate timeframes and barriers are relevant to all applications regardless of the type of technology being connected, and it is suggested that any changes should not necessarily be specific to storage (or any other technology).

At this stage, subject to the technical analysis of above, AEMO is content to leave the current technical requirements for connection in place and monitor whether any of these become barriers to connection.

1.2. Network service providers integrating storage

AEMO agrees that the characteristics of storage systems mean that they can be provided on a competitive basis and that there is a range of options that would allow network service providers to leverage the benefits of storage through commercial arrangements.

However, it is important to recognise that network service providers respond to the incentives established by the regulatory framework. Measures to support competition should be complemented by measures to ensure that network service providers adopt storage-based solutions where this is the most efficient option. Otherwise, there is a risk that they will find it more profitable to invest in traditional network-based solutions rather than non-network alternatives such as storage, even where the latter is more efficient.

The economic regulation framework in the NER was developed when meeting peak demand was the primary driver of network investment, and its focus is on augmentation expenditure. Changing market conditions mean that replacing ageing assets is now the primary driver of network investment. For example, in 2014-15, 85% of transmission network investment was replacement expenditure.

The regulatory framework needs to ensure that all network investment decisions are transparent and focussed on future needs, irrespective of which expenditure category the investment falls into.

To this end, AEMO supports the AEMC's recommendation in the Optional Firm Access Final Report[5] to extend the regulatory investment test to apply to replacement expenditure. There may be occasions where a storage provider can offer a more efficient solution than like-for-like replacement of an end-of-life network asset. The regulatory investment test is intended to ensure that networks consider all feasible options when making investment decisions.

AEMO also supports reforms to the requirements that Annual Planning Reports (APRs) should meet. Proponents of non-network services should be able to obtain a comprehensive understanding of upcoming network investment opportunities from APRs in a timeframe that allows them to develop and submit alternative solutions.

1.3. Control and ownership

1.3.1. Ownership

Where the ownership and/or control of storage systems sits, whether it is network service providers, retailers, customers, aggregators or some combination, the value proposition for the proponent will ultimately drive uptake.

The AEMC correctly identifies that the benefits of storage will be valued differently depending on the application, and that they do not necessarily overlap for all parties. In determining the optimisation of benefits, how each value stream is weighted needs thought. At present, there are many uncertainties over battery storage, both in terms of cost and technical performance. This makes any forecasts of uptake problematic. The study undertaken by CSIRO for the AEMC showed that the projected uptake of storage systems will reduce system peak. This may not necessarily true for all regions in the NEM

[5] AEMC, *Final Report – Volume 1, Optional Firm Access, Design and Testing, 9 July 2015*, pg iii. [Available at: http://www.aemc.gov.au/getattachment/147d4f18-5274-4310-8ce9-9569f0f48eaf/Final-Report-—-Volume-1.aspx]

depending on the time at which each regional peak (and local peak) occurs compared with the time of system peak.

Any benefits analysis will be sensitive to the underpinning variables that will drive storage uptake. AEMO's analysis to date in its Emerging Technologies Information Paper[6] released in July 2015 considered only customers owning storage systems and operating them to optimise the economic savings to themselves. This is likely to be a very different benefit than if the retailers or network service providers drove uptake.

1.3.2. Control

How a storage system is controlled and operated will depend on the value that a proponent wants to gain from it, and should be contestable. From the perspective of power system operations, AEMO needs detailed information about what is installed and how it operates regardless of who has control.

To operate the power system securely and reliably, and to provide the market with adequate information to support the high degree of decentralised decision-making that characterises the NEM, AEMO forecasts load and supply over different timeframes, from 5 minutes to 2 years. These forecasts are published to the market and continually updated. To prepare these forecasts, a level of detailed information across the full range of timeframes is required as input. The increasing penetration of small-scale generation over the last decade has resulted in AEMO losing some visibility of what is occurring at each transmission connection point. This could have the potential to create challenges when operating the power system.

This is evidenced by the large uptake of rooftop PV across the NEM in recent years. AEMO was able to adapt its processes as:

- Information about each installation was available from the CER, with whom each proponent was required to register in order to claim certificates under the Small-scale Renewable Energy Scheme.
- There is a degree of predictability in the electrical output from solar generation, depending on location, time of day, and season.

These factors enable AEMO to decipher the impact of rooftop PV at each transmission connection point across its different forecasting timeframes.

At the moment, there is no means of acquiring information about how many storage systems are installed in the NEM and how they are used. To fulfil its operational functions, AEMO will require information about storage systems connected to distribution networks. It is unclear how granular that information should be, and whether the current regulatory framework can facilitate access to that information[7]. Initially, at the very least, it is anticipated that the size, location and mode of operation of each installation will be required.

Understanding how the level of embedded storage can potentially impact the transmission system will be more challenging to discern than rooftop PV given the potential lack of predictability in the use of storage systems. The control and operation of these systems will determine when and how they charge/discharge. Without the information on the size, location and mode of operation of each system, AEMO will progressively lose the ability to predict the energy flow behaviour at the transmission connection points. This means, following high penetration of storage systems, AEMO will potentially face challenges in adequately informing the market to facilitate efficient, secure decentralised decision-making as performed currently, and ultimately, operating the power system.

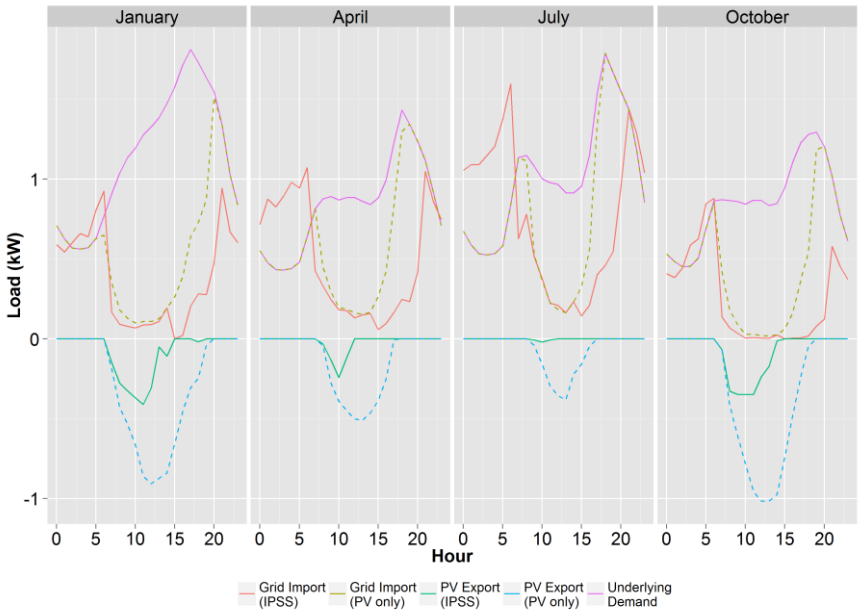
In particular, storage systems can be price-responsive, whether via aggregation or via individual households on time-of-use tariffs. If all, or a large, number of storage systems respond to the same signals, these could cause a large ramp-up or ramp-down in the space of a few milliseconds, which

[6] http://www.aemo.com.au/Electricity/Planning/Forecasting/National-Electricity-Forecasting-Report/NEFR-Supplementary-Information
[7] The demand side participation information that clause 3.7D of the NER is designed to facilitate is, as yet, untested.

could impact the operation of the power system. An understanding of the patterns of any ramp-ups or ramp-downs, when, and for how long, will assist AEMO greatly in being able to carry out its functions.

AEMO's Emerging Technologies Information Paper looked at the potential uptake and impact of residential battery systems. Figure 1 shows the average daily profile of a diversified large consumer household in Victoria for the months of January, April, July and October, and the impact of rooftop PV and integrated PV and storage systems (IPSS) on that profile. They are presented at an hourly resolution, and are averaged over the month. For this household, the red line indicates the demand for electricity from the grid. This demand has sharp peaks due to the configuration of the storage system and its response to time-of-use tariffs. If all households within the same distribution network also had storage systems that operate the same way, all systems would begin to charge/discharge at the same time, causing a sharp change in the network requirements.

Figure 1 Average daily profile for Victorian household with storage



For these reasons, consideration needs to be given not only to storage systems that are formally aggregated through registration as small generation aggregators, but also to the aggregated impact of individual storage systems, where there are high levels of localised uptake, that could affect power system operation. If AEMO has visibility on the level of storage uptake, as well as who has control over it, AEMO could develop strategies to adapt its operations.

The AEMC is considering whether it would be beneficial to introduce standardised requirements for the connection of storage capability.[8] Such arrangements could provide additional benefits if conditions were to include an obligation to provide the information that AEMO requires to maintain a secure power system. AEMO recognises that onerous obligations have the potential to stifle competition, so they would need to be carefully targeted and proportionate to the potential benefits.

[8] AEMC, *Integration of Energy Storage – Regulatory Implications, Discussion Paper 9 October 2015,* pg 15. [Available at: http://www.aemc.gov.au/Major-Pages/Integration-of-storage/Documents/Integration-of-Storage-Discussion-Paper.aspx]