# Submission to AEMC Review of Black System Event in South Australia: Issues and approach paper

**May 2019**

# Introduction

The AEMC's Issues and Approach Paper for its review of the black system event in South Australia touches on questions that go to the heart of power system operation in the NEM. AEMO welcomes this review, coming at a time when substantial work has been undertaken to pinpoint and address many of the challenges identified by the 2016 SA black system, but much remains to be done.

The physical properties of the power system are moving rapidly further away from the state that was assumed twenty, ten, or even five years ago. At the same time the type and severity of risks to power system integrity has been changing and continue to develop rapidly.

AEMO considers it is necessary to look beyond the market design parameters and system management options in the current NEM framework. Building and maintaining a secure and resilient grid is an urgent priority, but it is also a continually evolving challenge as the power system transitions to new technologies, increased consumer participation and different ways of interfacing with the market as economic and efficiency drivers change. Identifying, reducing and managing the current and future risks to the power system is no longer a 'set and forget' task. It will require an adaptable approach supported by a suite of flexible and complementary market, planning and system management tools. Those tools would ideally be deployed in a way that leverages opportunities presented by technological advances, efficiently allocates responsibilities and reduces the need for just-in-time management with its associated risk, reliability and price shocks.

AEMO looks forward to working with the AEMC throughout and beyond this review to identify what those tools might be, and how best to implement the necessary flexibility needed to maintain power system security and reliability in the transitioning and future power system.

AEMO's initial feedback on the questions raised in the Issues and Approach Paper are set out below. Sections are numbered to correspond with the question numbers in the paper.

# 1. Assessment framework

AEMO considers the assessment framework set out in the Issues and Approach Paper is generally appropriate for the review.

Noting the six-month timeframe allocated for the review and the fundamental challenges to be addressed, AEMO is supportive of an approach that uses the review process to inform and develop the priorities and scope for ongoing and new work to be further progressed in alternative workstreams.

The assessment principles are reasonable, but some may need to assume greater or lesser weight in light of the transition the power system is experiencing. For example, proportionality and flexibility need to be considered together. What may seem to be a proportionate response to address an issue now, may not be needed at all in a year's time, or may prove to be insufficient as conditions change. In these circumstances, flexibility assumes greater importance, as it could allow for the response to be wound back or extended as required. Effective allocation of risk and cost, as well as responsibility, is also necessary for flexibility to work well. Responsibility should be assigned in a way that prudently minimises the number of interdependencies and conditions on the power system needed to plan and act effectively.

The principle of technology neutrality in particular needs to be applied judiciously in the context of this review. The principle includes a statement that regulatory frameworks should not be targeted at a particular technology or be designed with a particular set of technologies in mind. While this is a valid objective, it is impossible to ignore the fact that technology is driving a change to the fundamental physics of the NEM power system. As the penetration of new technologies reduces the technical properties in the power system traditionally relied on to maintain stability and security, the NEM needs new technical capabilities to provide more of those technical properties in new ways.

# 2. Non-traditional system security risks and the contingency classification framework

Section 4.1 of the Issues and Approach Paper singles out wind turbine feathering for particular discussion as a risk or event that may warrant contingency management, drawing on the AER's compliance report. Feathering is, and was in the lead up to the SA black system, only one of several contributors to supply and demand variability within AEMO's 5-minute dispatch horizon. It was not a cause of the black system event.

There are many other factors that have a greater impact on supply and demand variability than wind turbine feathering. For example:

- Other dispersed and non-instantaneous variations in supply or demand. These include changes in output when the wind suddenly strengthens or weakens and clouds passing over solar plant in transmission and distribution networks, distribution network outages and other large variations in loads. Like wind turbine feathering, some can be forecast to some extent in the dispatch timeframe, and are considered by AEMO in its operational forecasting systems and processes. Further information can be provided to the AEMC if required.
- Semi-scheduled generators shutting down or reducing for technical reasons or in response to price. Semi-scheduled generators are not obliged to follow dispatch targets and can respond to any technical issue by changing their local set point to reduce or cease output. AEMO has also observed occasions where semi scheduled plant output reduces to zero when the regional reference price falls below zero, but no rebid is submitted. If continued, the potential impact of this type of response will be significantly greater under a 5-minute settlement regime.
- Contingency events causing a large volume of generation runback schemes to operate. A single credible contingency in the network, e.g. the loss of a single line can cause runback schemes to operate. Clusters of new generation connected with runback schemes could all reduce output significantly, creating a combined large reduction in supply.

As the installed capacity of grid-scale wind and solar generation grows, and penetration of rooftop PV and other distributed energy resources expands rapidly, there is increasing potential for the combined risks associated with weather-dependent and similar-type technologies to impact on power system security. At the same time, more frequent extreme and unpredictable weather events further increase the likelihood of occurrence.

AEMO considers that the existing contingency event reclassification framework cannot be applied to most of these risk types without rule changes. More fundamentally, reclassification is unlikely to be an efficient means of mitigating these risks.

### Reclassification framework

AEMO, in consultation with the Power System Security Working Group, is in the process of reviewing the reclassification criteria in its power system security guidelines. The review is considering reclassification criteria for increased risk due to:

- Bushfires.
- Lightning.
- Severe weather events including, flood, tsunami, cyclone, drought, hail, dust and wind storms.
- Multiple generation unit disconnections.

- Impacts of pollution.
- Impacts of protection or control system malfunction.
- Solar storms and geomagnetic disturbances.
- Solar eclipse.
- Forecast uncertainty.
- Other events which may present as risks to power system security.

The AEMC's paper notes that there may be differing interpretations of contingency events – a 'traditional' view of a contingency as a specific, instantaneous event, or one that allows for contingencies to span slower, distributed events over the course of a 5-minute dispatch interval.

AEMO considers that the current rules definition of a contingency event allows very little flexibility to depart from the 'traditional' interpretation. The contingency rules and definitions reflect the system for which they were clearly designed at the start of the NEM; they were considered appropriate and proportionate for the types of risk that could not be managed through five-minute dispatch in a system where firm supply could be scheduled to meet demand every five minutes. The reality in the NEM is now very different.

Even if the contingency framework were broadened, managing the risks discussed in this section as a contingency event and reclassifying could result in highly inefficient economic outcomes, potentially requiring significant capacity to be held in reserve on a regular basis. In tight supply conditions, this would almost certainly result in more frequent load shedding to maintain a secure operating state. This said, AEMO does consider that these non-traditional risks will become increasingly challenging to manage through dispatch unless appropriate frameworks are developed to reduce the both the amount of supply variability and its impact.

## Alternatives to manage or reduce variability of generation

### The FUM

AEMO developed and implemented the forecast uncertainty measure (FUM) in 2017-18 using a Bayesian Belief Network, to better account for the increased number and extent of factors that create uncertainty in demand and supply forecasting in pre-dispatch and dispatch timeframes. While the FUM is applied to manage reserve levels, the lack of reserve (LOR) framework is also underpinned by power system security needs. AEMO is investigating the application of probabilistic forecasting and Bayesian techniques (used in the FUM) to quantify risks and uncertainty associated with specific events such as solar ramping and timing of weather fronts.

### Self-forecasting and dispatch of intermittent generation

AEMO and ARENA have commenced a market participant 5-minute self-forecast project, where intermittent generation participants are able to submit their own dispatch forecast to AEMO, to be used in place of the AWEFS dispatch forecast. In this instance it is expected that the participant self-forecast will inherently reflect impacts under high wind-speeds including wind feathering. However, as long as there is no requirement for semi-scheduled generators to achieve their forecast dispatch level, variability will remain challenging to manage, particularly in a 5-minute settlement system.

AEMO studies have shown that the installation of a battery of around 10% of a wind farm capacity could enable in excess of 90% of 5-minute forecast uncertainty to be overcome.

### Accurate power system equipment models in changing conditions

The AEMC made the Generating System Model Guidelines rule in 2017. AEMO subsequently issued new Power System Model Guidelines in 2018. Registered participants and connection applicants must now give AEMO and NSPs information and models that more accurately represent the range of conditions likely to be experienced in the transitioning power system. It is becoming increasingly necessary for AEMO to obtain RMS-type models to be able to predict plant responses to faults in normal and outage conditions.

Although the rules and guidelines have provided the framework within which AEMO can obtain better information and modelling, in practice this is a slow process, made more challenging by the unprecedented high volume of connections being progressed simultaneously in many areas of the NEM and the different modelling and information release approaches taken by original equipment manufacturers.

### Grid support in the NEM and overseas

Mechanisms to manage variable energy source volatility are critical to a future grid state with universally high variable energy penetration. In a grid where synchronous generation is increasingly displaced in some periods by asynchronous generation and distributed energy resources, AEMO now needs to take measures to secure more of the grid support that helps to maintain stability and increase resilience to larger variations.

AEMO is already using existing measures to do this, for example by increasing the quantity of regulation frequency control and directing to maintain system strength and reactive support, but these are certainly not efficient long term solutions.

The system strength services framework introduced in 2017 is being used in South Australia to procure longer term solutions, and the AEMC is already reviewing the effectiveness of that framework[1]. In some circumstances non-market ancillary services contracting can assist and in the long term effective, efficient and consistent planning of network investment will be vital. All of these things need to be appropriately incentivised through the regulatory frameworks. However, tools that can be used by AEMO as system operator to manage variability in dispatch are vital.

As noted in section 1, technology and efficient risk and responsibility allocation should inform how the critical needs of the power system are best met. Some grid operators in the United States and Europe have a significantly greater ability to manage the commitment of generation by utilising arrangements such as:

- Ramping services based on day ahead forecasts.
- Minimum must run regimes.
- Firming capacity.
- Primary frequency response requirements.

Many jurisdictions have discovered the need to improve the short-term real time balancing of supply with demand. In all cases one of the major improvements resulted from the introduction or tightening of primary frequency response. In overseas systems this has been achieved through a range of different frameworks including markets, auctions, tenders and mandates.

In 2018, the Federal Electricity Reliability Council of the USA (FERC) mandated primary frequency response for all new generation, both synchronous and asynchronous (excluding nuclear and co-generation plants). The FERC requirement followed the same requirements in place in Texas which realised significant improvements in regulation of frequency (the balance of supply and demand).

[1] AEMC, Investigation into intervention mechanisms and system strength in the NEM, Consultation paper, 4 April 2019

# 3. Reclassification criteria and guidelines

In section 4.2 of the Issues and Approach Paper, the AEMC asks a number of questions about the process AEMO follows in assessing whether a non-credible contingency event should be reclassified as credible, and about the scope of the reclassification criteria within the existing rules framework.

## Reclassification decisions

It is important to clarify at the outset that AEMO neither seeks nor relies on participants' opinions about whether AEMO should reclassify a non-credible contingency as credible. This decision is for AEMO alone to make.

AEMO can only make a reclassification decision after assessing the information necessary to understand the likelihood that a particular contingency event will occur. For those purposes it is entirely appropriate for AEMO to rely on the advice of network operators and registered generators on the condition of their own assets and any current risks to those assets – whether presented by environmental conditions or circumstances specific to the plant.

Reclassification is based on AEMO's assessment that a normally non-credible event on the power system has become reasonably possible. As such, reclassifications occur when changed circumstances or conditions present material added risk to the power system, in accordance with the established reclassification criteria[2].

To make reclassification decisions AEMO requires and relies on accurate, up to date and relevant information on any risks to the condition, performance or behaviour of equipment or services in the power system. The asset operator will have considerably more knowledge of the asset and immediate risks to it than AEMO. AEMO will ask for information when it is aware of abnormal circumstances potentially impacting the equipment. However, registered participants must also volunteer relevant information to AEMO about increased risks that could be expected to impact power system security, when they become aware of them[3].

## Reclassification criteria

As mentioned in response to question 2, AEMO is presently reviewing the reclassification criteria in relation to a range of potential abnormal conditions that could threaten power system security. AEMO would like to make the following further observations on the limitations of reclassification criteria.

- Detailed reclassification criteria can only be developed in relation to a contingency event if it is likely to manifest in a way that allows magnitude and impact to be measured by reference to a fairly consistent set of criteria or indicators. In many cases it will not be practical or possible to determine those in advance, so it is essential that flexibility and discretion is maintained in the assessment process.
- The present reclassification framework requires AEMO to identify and specify any non-credible contingency event[4] that is more likely to occur because of abnormal conditions. In circumstances where there are abnormal conditions that might impact the power system in general, but no specific asset has been identified as being at particular risk, it is unclear how reclassification can be applied – or whether it should be.
- The reclassification rules and criteria do not allow for AEMO to assess the probable consequences of a contingency event when considering reclassification. The AEMC asks whether this is a factor that should be considered. Within the current reclassification framework under which these decisions are undertaken in response to real time situations, this would be inadvisable. It would delay decision-making and increase risk and liability. If the system is allowed to become insecure because it was deemed the consequence was

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[2] The reclassification criteria are published in AEMO's Power System Security Guidelines (SO_OP_3715).

[3] Clauses 4.8.1, 4.3.3 and other more specific National Electricity Rules obligations require participants to give relevant information to AEMO. In the absence of contrary information, AEMO is entitled to assume that power system equipment will perform consistently with registered performance standards.

[4] By definition, a contingency event is one that is likely to involve the failure or removal from operational service of one or more generating units or transmission elements (only)

low, the risk of cascading events would be higher because AEMO does not comprehensively study and cannot foresee the response of equipment outside normal and credible contingency conditions. AEMO therefore considers that the focus of reclassification decisions should remain on maintaining secure operation within the technical envelope.

### Reliability Panel guidelines

The AEMC's paper observes that the Reliability Panel has not developed any principles or guidelines to determine how AEMO should maintain power system security while taking into account the costs and benefits[5].

AEMO considers there may be merit in the Reliability Panel developing such principles and guidelines, if that were done in the context of a more flexible framework for managing power system security than the current rules allow. The rules should provide for a broad framework that:

- Incentivises performance that assists system security.
- Allows AEMO to manage the range of system security risks confronting the NEM now and in the future.
- Can be flexibly applied to changing circumstances to ensure management of system security is fit for purpose, and as efficient as it can reasonably be.

Within a more flexible rules framework there would be a clearer role for Reliability Panel guidelines, as long as they are regularly revisited and assessed.

# 4. Interaction between the reclassification and protected event frameworks

The protected events framework allows AEMO to recommend a non-credible contingency be classified as a protected event, allowing AEMO to take operational action to manage the risk within the parameters declared by the Reliability Panel.

It is difficult to assess interactions between the reclassification and protected events frameworks in practice. To date only one protected event has been recommended, and that has not yet been declared by the Reliability Panel. Certainly, AEMO would not recommend declaration of a protected event where it considered the reclassification framework was adequate to manage the associated risk.

AEMO does consider that the protected events framework has a number of shortcomings, however, with the benefit of experience since the framework was introduced in 2017. These include:

- The time needed to identify, develop, review and eventually declare a protected event is too long to keep pace with the rapid transition in the power system. This leaves no option but for the AEMO to intervene where it is possible to do so, often in costly ways. In that time, the rapid pace of change in the network means that the nature of the risk will most likely have changed, and different challenges may be presenting.
- The protected events framework addresses only non-credible contingencies that cause frequency disturbances identified as part of a Power System Frequency Risk Review. Non-credible contingencies can cause significant disruption via other phenomena without directly being frequency disturbance events, for example:
  - Voltage collapse.
  - Oscillatory instability.

[5] As contemplated by clause 8.8.1(a)(2a) of the National Electricity Rules.

  - Transient instability.
  - System strength.
- Like reclassification, the protected events framework only addresses risks of non-credible contingencies in the context of dispatch and real time system security management. In practice it will never be possible to identify every discrete non-credible contingency that would have an unacceptably high impact if it occurred.

These shortcomings mean, in effect, that most of the risk of high impact, low probability events will remain un-mitigated. For this reason, general improvements in system resilience with broad applications to many events (for example by increasing the amount of inertia and frequency droop control in the system) when combined with a more flexible reclassification framework are likely to be far preferable and more efficient than a protected event.

# 5. Roles and responsibilities of the NSP in SRAS testing and system restart services

Since the black system event, and following the Reliability Panel's determination of a revised system restart standard, AEMO substantially revised its SRAS guidelines. Among several other changes, the guideline and standard SRAS contracts incorporate explicit requirements for NSP involvement in procurement and ongoing testing of system restart services.

AEMO considers that these changes address a number of the issues raised by the AER. However, further changes are desirable that require changes to the National Electricity Rules.

AEMO is preparing a rule change proposal to address some of the most critical ongoing and emerging challenges for effective supply restoration in the transitioning power system. The withdrawal and aging of synchronous plant, its displacement with asynchronous resources in remote areas of the grid, reduction in the number of large stabilising loads and significant penetration of distributed energy resources are all contributing factors to a decline in both the availability and effectiveness of traditional SRAS sources.

AEMO's rule change proposal will include expanded roles and responsibilities for network service providers in relation to their involvement in ongoing testing of contracted SRAS and verifying the effectiveness of system restart paths into their networks.

The ongoing transformation of the NEM power system makes it increasingly difficult to establish by modelling alone whether the SRAS acquired by AEMO is effective for system restart. Merely testing the performance of an SRAS itself to deliver electricity to a transmission network connection point is no longer sufficient. A reasonable level of assurance is needed that, as network conditions change, electricity can be delivered from the SRAS source to a point within the transmission network from which sufficient generation can be reliably energised to meet the system restart standard.

Extending the testing beyond the SRAS provider's connection to energise nearby network elements will help to confirm the capabilities of the service, validate the restart plans and assist in identifying and resolving unexpected issues that could otherwise manifest during an actual restoration event. More specifically, extended testing can assist in:

- Verifying the capability to energise nearby large transformers and transmission lines, and downstream distribution loads.
- Identifying any unknown control or protection scheme arrangements that could affect restoration and which may not otherwise be known until a blackout occurs.

There is currently no basis in the NER for AEMO to require such tests to be conducted, and funded, or for NSPs and other registered participants to facilitate them. AEMO's rule change proposal will seek to address this gap.

# 6. Role and content of the local black start procedures

AEMO has historically used information provided by NSPs and generators in their local black start procedures (LBSP) as input data for:

- Power system studies conducted during the SRAS procurement process to ensure the limitations and capability of all generating systems are accounted for to achieve a SRAS procurement compliant with system restart standard.
- Developing system restart plans accounting for the entirety of each electrical sub-network.
- Creating system restoration curves to assist the Reliability Panel (in 2016) in its determination of the system restart standard.

When considering the sufficiency of information in LBSPs, it is important to recognise that the information needed for different types of power system equipment will be different depending on how it is likely to be involved in a power system restoration. This is explained below.

- **Synchronous SRAS generation** – AEMO has generally received comprehensive information on generating units procured as SRAS sources. Most this information is verified during mandatory testing of SRAS sources.
- **Synchronous non-SRAS generation** – the level of details and accuracy for synchronous generation not procured by AEMO for SRAS is variable, in many cases due to inaccurate or missing models. During the most recent procurement process, AEMO contacted all large synchronous generators to specifically request up-to-date information consistent with the current LBSP template. For smaller units, the level of information provided could vary largely depending on the size and the last time they have undergone an upgrade. It is also noted that aside from procured SRAS sources, the accuracy of information provided for other synchronous generators is not generally verified and AEMO assumes it is correct and up to date.
- **Asynchronous generation** – as most asynchronous generating systems have been connected in recent times, the level of information provided is generally consistent with the most recent LBSP template. However, AEMO recognises that the template is geared towards synchronous generation technologies, and their requirements and limitations during a major supply disruption. AEMO expects to consult with generators in the second half of 2019 on improvements to the template to cater for rapidly evolving asynchronous generation technologies. Better LBSP information that more accurately represents the capabilities and limitations of asynchronous generating systems may allow increased utilisation of this plant during system restoration.
- **Network service providers** – AEMO recognises that there are also opportunities to better capture the requirements and limitations of network equipment in black system conditions as the power system changes rapidly. AEMO intends to consult with NSPs in 2019 about improving the LBSP template for NSPs to include:
  - Criteria and conditions for switching in network static or dynamic reactive support plant during system restoration.
  - Changes required to network control and protection schemes or associated parameters between system intact and during restoration.

- Role of synchronous condensers during system restoration as they are increasingly considered in various regions to replace aging synchronous generation.

Increased connections of large-scale generation at the distribution level indicates there may be a need for:

- More direct communication protocols between AEMO and DNSPs.
- Better representation of the expected behaviour, limitations and potential support capabilities of distributed energy resources.

# 7. Applicability of market rules during market suspension

AEMO considers that the issues raised in section 6.1 can be addressed by the application of flexible principles rather than detailed enumeration of obligations that should, should not, or could apply during a market suspension.

The range of potential conditions of the power system and circumstances surrounding a market suspension is wide and varied. As such, a framework that restricts options or prescribes rules that need to be applied in an unfamiliar way presents greater risk and potential for chaos in these rare and extenuating circumstances.

AEMO considers it would be appropriate and sufficient for the rules to reflect the principle that AEMO will always endeavour to operate the power system and market during suspension in accordance with the rules to the extent it is reasonably practicable to do so.

# 8. Quick energy constraints as system security interventions

AEMO does not use quick constraints as a standalone intervention measure. The use of quick constraints is in line with current processes to manage power system security[6] and should not be confused with directions.

AEMO control room operators use quick constraints where necessary to build and invoke network constraint sets and equations in a fast, flexible way. This capability is primarily required to address system security issues in scenarios representing risks to system security where a constraint is urgently required and does not exist in AEMO's extensive constraint library. Quick constraints are also used to limit output of new generators during commissioning. The use of quick constraints avoids AEMO having to pre-determine every possible future scenario where a constraint may be required and avoids the maintenance of a vast library of all constraints with all the generator values. AEMO presently has a constraint library of over 10,000 constraints.

During the extended period when market suspension pricing applied after the SA black system, but while AEMO was attempting to operate central dispatch in accordance with the rules, quick constraints were also used on occasion to implement dispatch instructions that generators had confirmed they would comply with consistent with their bid availability, and to implement any formal AEMO directions. They were not used as standalone interventions.

[6] As outlined in PSSG OP_3715 section 5.

Since the black system event, AEMO has reviewed and updated its internal direction processes to ensure that its communication is as clear as possible when issuing directions. AEMO is also currently consulting on its public procedure for the issue of directions and instructions.

# 9. Suspension pricing

In its final report on the SA black system event, AEMO recommended actions to improve the framework for market suspension pricing. Those recommendations, including associated rule changes as outlined in the AEMC's paper, are complete. AEMO considers they are likely to provide a significantly clearer and more manageable pricing regime, and have allowed for the automation of key processes.

# 10. Arrangements for enhancing power system resilience

AEMO notes that resilience covers a much broader scope than traditional power system security (contingency) concepts as they have been applied in the NEM to date.

Resilience cannot be prescriptively defined, either in respect of the risks that threaten it or the available responses to maintain or restore it. Non-system risks also present risks to resilience over different timeframes from immediate to several years. Examples include insufficient planning and development[7], natural disasters, physical or cyber-attacks, compound impacts associated with climate change, and fuel security. AEMO's role is to manage the potential impact of a variety of known and unknown future risks on the power system. The regulatory framework needs to allow enough flexibility to do so.

The nature and extent of risks arising from events or circumstances external to the power system is changing. At the same time, the evolution of the power system itself presents new risks, previously rare electrical phenomena and changing impacts of contingency events. For example:

- The transition of generation in Australia from a fleet based on thermal and hydro machines to one with a large component of variable renewable and distributed generation brings greater exposure to weather-related power system events, exacerbated by the increasing frequency and severity of such events.
- New supply technologies are largely controlled by similar-type, proprietary, remotely-programmed software increases the prospect of multiple contingency events extending beyond the traditional risks managed through the power system security framework, including coincident technology-type failures and events like cyber-attacks.

AEMO considers that efficient, planned provision of essential capabilities such as primary frequency response and reactive power support combined with appropriate infrastructure development and cyber security uplift will be critical to maintaining a resilient system.

In its role as power system operator, AEMO is setting appropriate priorities to enhance resilience, including through:

a) Rule changes proposing greater frequency response requirements from all generators.

b) The Integrated System Plan that sets out the roadmap for the infrastructure and assets required to maintain a secure and reliable power system.

[7] The Energy Security Board's current consultation on converting the Integrated System Plan into action also considers how to account for resilience in the transmission planning framework.

c) Digital transformation and cyber security uplift in accordance with the Australian energy sector cyber security framework.

### Cost impact of HILP events

With respect to methodologies to determine costs of high impact low probability outages and black system events, AEMO and the AER are presently reviewing the value of customer reliability (VCR) including improvements to the economic assessment of customer impacts from black system events and other major loss of supply events.