18 August 2017

Level 17
197 St Georges Terrace
Perth WA 6000

Postal Address:
PO Box 7096
Cloisters Square
Perth WA 6850

T 08 9254 4300
F 08 9254 4399

Neville Henderson
Chair
Reliability Panel
PO Box A2449
Sydney South NSW 1235

Dear Mr Henderson

Review of the frequency operating standard, stage 1 – request for advice

This advice is in response to the request of the Reliability Panel dated 1 August 2017 for AEMO to provide further detail on aspects of Stage 1 of the Review of the Frequency Operating Standards (FOS). Specifically, to inform and support the Panel's determination of the FOS, AEMO's advice has been sought on:

1. Inclusion of a standard to apply to protected events.
2. Amendments to the requirements for multiple contingency events.
3. The inclusion of guidance for the characteristics of an 'electrical island'.
4. Review of the requirement for accumulated time error in the FOS.
5. Review of the definition of terms in the FOS, particularly the definition of a generation event.

AEMO is pleased to provide the attached response to the Panel and has included quantitative assessments where possible given the time constraints of the advice. AEMO is happy to provide further advice to the Panel on these matters as needed during the review process.

If you have any queries please do not hesitate to contact Matthew Holmes, Principal – Power System Development via matthew.holmes@aemo.com.au or (07) 3347 3039.

Yours sincerely

C Parrotte

Cameron Parrotte
Executive Group Manager, Strategy and Innovation

Attachment 1: AEMO response to request for advice

The Panel provided specific questions for AEMO to consider, and in all five categories, AEMO has been asked to provide advice on the timing and criticality of implementation of any changes to the FOS following this review. The full request for advice has been provided at Attachment 2.

1. Inclusion of a standard to apply to protected events

AEMO has been requested to advise on what frequency bands should apply for protected events in the National Electricity Market (NEM), including consideration of the stabilisation and restoration bands and timeframes.

AEMO considers the interim frequency standard settings as set out in the final protected events rule (National Electricity Rules (NER) clause 11.97.2) as appropriate and has not identified any reason to vary from them. These interim frequency standard settings are as follows:

> "For a protected event, system frequency should not exceed the applicable extreme frequency excursion tolerance limits [47.0 to 52.0 Hz] and should not exceed the applicable load change band [49.5 to 51.5 Hz for the mainland, slightly broader for Tasmania or islanding conditions] for more than two minutes while there is no contingency event or the applicable normal operating frequency band for more than 10 minutes while there is no contingency event"

These interim settings are based on the multiple contingency event settings in the existing FOS. This linkage was based on the fact that protected events most likely will include multiple contingency events.

Given protected events are special nominated events, each event will be different and each mechanism selected to protect against the event may be different. In this sense, the broad frequency obligation is appropriate, providing flexibility in operational response and economic efficiency to be realised. As one example, setting a tighter frequency band may require substantial regional frequency control ancillary services (FCAS) to be sourced pre-emptively as a normal practice (for example, even under non-credible chance of separation situations), which is likely to come at high cost.

While a broad frequency band means that some load shedding may be allowable as a result of a protected event occurring, this is consistent with the purpose of protected events. The protected events scheme is intended to protect against major consequences such as uncontrolled and significant load shedding or the loss of a region. It would be in planning the protection mechanism for each nominated protected event that AEMO would evaluate the most cost effective options for implementing that protection, and in this evaluation would take into consideration the relative costs and benefits of options that can potentially better contain frequency.

AEMO also considers the interim stabilisation and recovery bands and timeframes applied following protected events under NER clause 11.97.2 are appropriate for both the NEM mainland and Tasmania.

Given the interim standards are considered suitable, AEMO acknowledges that there is less urgency to revise the FOS to accommodate protected events. However, since this

requirement was the key driver for the current FOS review, and it is proposed to adopt the interim standards unchanged, Stage 1 is the logical opportunity to implement this change.

2. Amendments to the requirements for multiple contingency events

The Panel has asked for AEMO's view on the proposed amendments to the requirements in the FOS for multiple contingency events, as follows:

> "as a result of any multiple contingency event, AEMO should use its best endeavours to:
>
> (i) maintain system frequency within the *extreme frequency excursion tolerance limits*; and
>
> (ii) avoid the system frequency exceeding the applicable generation and load change band for more than two minutes while there is no contingency event or exceed the applicable *normal operating frequency band* for more than ten minutes while there is no contingency event."

AEMO disagrees with these proposed amendments. The protected events framework has provided clarity to AEMO's power system security responsibilities in relation to contingency events. As raised in the original protected events Rule change proposal lodged by the South Australian Minister for Mineral Resources, this feature of the current FOS clouds obligations for maintaining system security.

AEMO's submission to the Rule change commented on Part B (f) of the FOS, which requires that the extreme frequency excursion band not be exceeded for any multiple contingency event[1]. Read literally, this provision is unworkable, because it rests on the incorrect assumption that any multiple contingency event can be managed. Before the protected events rule change, AEMO interpreted this band as a target that informs the settings of the mechanisms available to AEMO to respond to non-credible contingency events. Currently these are limited to automatic under-frequency load shedding (UFLS). AEMO considered this interpretation was consistent with the previous version of NER clause 4.2.6(c).

AEMO's power system security responsibilities, and the limits on those responsibilities, are a cornerstone of the power system security framework set out in the NER. The NER recognise that (with the exception of the new protected events category), it is not economically feasible to manage the power system so as to ensure it will land in a satisfactory state after multiple or non-credible contingencies. For these situations emergency frequency control schemes (EFCS) should operate as a last line of defence. The revisions to clause 4.2.6 clarify this, and make the multiple contingency event provisions in the FOS redundant except as a trigger for the operation of EFCS[2].

AEMO proposes that the application of this section of the FOS be modified to apply to protected events, which may be managed both through EFCS and other ex-ante actions reasonably necessary to maintain power system security should those events occur.

AEMO understands a number of stakeholders and Panel members have expressed concerns regarding the removal of any specific provision for multiple contingency events from the FOS. A particular concern noted was that this would then remove justification for protection schemes such as UFLS. However, the responsibilities of AEMO and network service providers (NSPs) in relation to multiple contingency events are now clearly defined in the

[1] http://www.aemc.gov.au/getattachment/15b4c5c7-fc2b-4b73-a012-af0ec28f7a69/AEMO.aspx
[2] For example refer to clause 4.3.5(a) and (b) of the NER.

Rules and linked to the FOS such that they do not need to also be explicitly defined in the FOS. NER clause 4.2.6, as amended by the protected events rule, states that:

> Emergency frequency control schemes should be available and in service to:
>
> (1) restore the power system to a satisfactory operating state following protected events; and
>
> (2) significantly reduce the risk of cascading outages and major supply disruptions following significant multiple contingency events.

AEMO also highlights the following NER obligations associated with multiple contingencies:

- Clause S5.1.3 requires NSPs to ensure their plant operates normally for frequencies within the extreme frequency excursion tolerance limits.
- Clause S5.1.10.1(a) requires NSPs to ensure there is sufficient load connected to UFLS relays to reduce the risk of frequency moving outside the extreme frequency excursion tolerance limits for multiple contingency events.
- Under clause 4.3.5, market customers with expected peak demands greater than 10 MW are required to have at least 60% of their load connected to the UFLS scheme to assist in managing under-frequency conditions as specified in the FOS.

Further, AEMO has a system security responsibility to arrest the impact of significant multiple contingency events and coordinate the provision of load shedding and EFCS in accordance with clauses 4.3.1(k)(2) and (pa). AEMO is also responsible for planning for non-credible contingency events and specifying EFCS where warranted (clause 5.20A). Then, in accordance with clause 4.3.2(h), AEMO must “develop, update and maintain” (in consultation with NSPs and jurisdictional bodies) a set of procedures and schedules for each jurisdiction detailing how load shedding and EFCS will operate in those jurisdictions. The operation of UFLS schemes comprise part of these procedures and schedules.

In combination, these clauses that link to the extreme frequency excursion tolerance limits (and therefore to the FOS Part C since it is where the frequency limits are designated) provide a framework for AEMO to determine settings for EFCSs such as UFLS. Therefore AEMO considers that there is no need for the FOS to contain an explicit band related to multiple contingency events. Any reference to multiple contingencies needs to be removed at the same time as the inclusion of the protected events standard.

3. The inclusion of guidance for the characteristics of an 'electrical island'

The suggested approach that has been proposed for revising the definition of an electrical island in the FOS is as follows:

> “*electrical island* means a part of the *power system* that includes *generation*, *networks* and *load*, for which all of its network connections with other parts of the power system have been disconnected, provided that the part:
>
> (a) does not include more than half of the generation of each of two regions (determined by available capacity before disconnection); and
>
> (b) is at least equal to or greater than an *inertia sub*-network.”

This definition of inertia sub-network will be added to the definitions in the FOS:

> “*inertia sub-network* has the meaning given to it in the rules.”

AEMO supports this revised definition of an electrical island as it provides a workable minimum bound to the definition of an electrical island and links to a definition to be specified in the Rules. Inertia sub-networks are intended to be areas that can be managed in a secure operating state, which by definition implies adequate control of frequency. Therefore this linkage is sensible and practical.

Ambiguity in definition of an electrical island should be addressed as soon as practical. Operating a power system in the most efficient way depends on the clarity of the governing Standards.

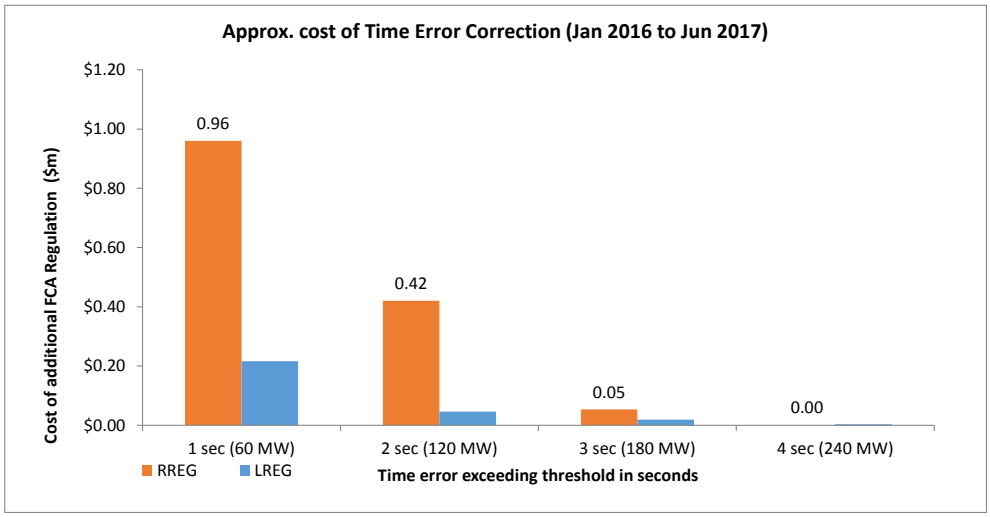
4. Review of the requirement for accumulated time error in the FOS

AEMO has been requested to provide quantification of the historical cost of time error correction in the NEM mainland and Tasmania, system security considerations, and the benefits and costs of removing the obligation to perform time error correction.

Quantifying the cost

AEMO has performed an assessment of the historical cost of time error correction in terms of increased FCAS regulation procurement. This should provide a reasonable estimate of ongoing costs if no significant changes are made to time error correction itself, or the typical prices offered in the FCAS regulation markets.

Over the 18-month period spanning January 2016 to June 2017[3] additional regulation FCAS was procured approximately 1% of the time due to accumulated time error exceeding the ± 1.5 second threshold. This corresponds to approximately $1 million per annum as shown in the figure below (note that the figure covers the 18-month period analysed):



This analysis is considered an upper limit to the amount of regulation FCAS that may be avoided by eliminating time error correction. This is because it is reasonable to expect that some of this additional regulation FCAS would be procured in any case for the purposes of managing frequency (rather than time error). AEMO has not been able to assess this in the time available. Nonetheless, the removal of time error correction can only cause a reduction

[3] Attempting to go further back in time would introduce complication due to changes in FCAS constraints.

in the level of regulation FCAS that would otherwise be procured, and never an increase. This means that in the absence of other changes, removal of the obligation to contain time error cannot result in increased FCAS costs.

System security considerations

AEMO considers that there are no system security (or reliability) benefits specific to conducting time error correction. This aligns with the reasoning of the North American Electric Reliability Corporation (NERC) in its recommendation to remove the obligation of time error correction in the US[4]. If there remain some consumers dependent on an accurate grid time-keeping service, in AEMO's view this would better characterised as a power quality issue rather than a security or reliability issue.

Costs, benefits and implications of relaxing or removing the standard

Relaxing the requirement for a limit on accumulated time error could be implemented at minimal cost to AEMO, and may involve solely changing time-keeping parameters in the Energy Management System (EMS)[5].

Complete removal of the requirement for a limit on accumulated time error would entail more effort and resources. AEMO expects the following changes would need to be made:

- Time-keeping parameters in the EMS would be modified to remove their effects.
- Dynamic regulation FCAS constraints would need to be re-formulated to use an alternative trigger rather than time error. Integral Area Control Area (ACEINT), a measure of accumulated frequency deviation, may be suitable.
- The FCAS Causer Pays model would be reviewed to check for any impacts (some effect likely, but expect this to be relatively straightforward to deal with).
- System operating procedures should be reviewed and any revisions made (likely to be minimal).

There are reasonably common instances where time error correction acts in a manner contrary to good frequency control. This means that time error correction results in poorer frequency control, which impacts system security negatively (noting that the impact is not regarded as severe). This is a topic that has been investigated through work with the Ancillary Services Technical Advisory Group (AS-TAG) on frequency control degradation within the normal operating band.

This counter-frequency action driven by time error correction occurs legitimately based on how accumulated time error is corrected. For example:

- If frequency has been above 50 Hz for some time, the time error will be positive. That is, clock time as measured from the grid frequency will be fast.
- To correct this, the grid frequency needs to be reduced, and is done so by reducing generation supply[6].
- In the instance that a disturbance on the power system occurs concurrently (such as the trip of a generator) which results in the frequency falling below 50 Hz, then the

[4] https://www.naesb.org/pdf4/ferc032717_time_error_correction_status_report.pdf
[5] For clarity, the AGC (Automatic Generation Control) system is a sub-set of the EMS.
[6] This is done using a small adjustment to the target system frequency in the EMS. An offset of up to +/- 0.05 Hz from the nominal target frequency (50 Hz) is employed.

adjustment factors for time correction will be countering the adjustment factors for frequency correction.

This counter-action feature is by design, and is consistent with other jurisdictions internationally. When time error is generally very low, this behaviour is relatively insignificant. However, if the management of frequency control within the normal operating band deteriorates such that frequency is less tightly bound around 50 Hz, time error often accumulates to significant amounts. This can then become an issue for good frequency control. AEMO's analysis has shown that this 'counter frequency' behaviour can occur up to 20% of the time. A relaxed time error requirement would allow AEMO to use less aggressive time error correction settings, better prioritising good frequency control. Eliminating the obligation to contain time error entirely will eliminate these conflicting objectives and more fully prioritise good frequency control.

From a more general perspective, removing unnecessary obligations is prudent as it streamlines operating practices.

The Panel has also asked whether, to AEMO's knowledge there are any critical processes or equipment that would be adversely impacted by the removal or relaxation of the requirement to limit accumulated time error. AEMO is not aware of any critical processes or equipment that would be adversely impacted by these proposed changes. AEMO is also unaware of any complaint being received concerning time error. However, those potentially impacted may not be customers with whom AEMO has typically had direct interaction.

Overall, AEMO is supportive of a removal or relaxation of the requirement, subject to satisfactory consultation to understand and evaluate any as-yet unknown impacts to customers. AEMO believes that the removal of the *obligation* to limit accumulated time error could be implemented relatively quickly as it would not force any immediate changes. AEMO is also able to phase in changes as appropriate.

Given AEMO's current work on frequency control performance through AS-TAG has indicated that time error correction can have potentially undesirable interaction with frequency response of AEMO systems, there is sense in pursuing its review. If the Panel judges that the Stage 1 timeframe does not provide adequate time for consultation with other parties, a phased approach to removal of time error correction could be considered with the aim to finalising its removal in Stage 2.

5. Review of the definition of terms in the FOS (definition of a generation event)

Proposed approach to revising the definition of generation event

AEMO is requesting the revision of the definition of 'generation event' in the FOS as the current definition is unclear, is too specific to particular kinds of events, and does not adequately capture new and potentially emerging types of rapid, unexpected generation events. In particular, it does not cover rapid, unexpected changes in generation from sources.

AEMO's proposed approach is for the revised FOS in Stage 1 to expand the definition of generation events to be clearly mapped to a credible contingency generator event in the NER, which provides for AEMO to define credible contingency events under Clause 4.2.3 to allow reasonably possible generation events to be declared credible.

Changing nature of generation events

As the generation mix evolves to one of more variable generation, large ramps in generation over short periods from plant are possible, for example from solar during intermittently cloudy days. Generation from utility-scale solar plant in the NEM has been observed to change by up to 80–90% of rated capacity in five minutes, or as much as 101 MW in five minutes for a 103 MW plant. Changes in output of greater than 50% of rated capacity over handfuls of seconds have been observed at all existing solar farms (that is, up to 50 MW and even higher).

This type of behaviour is anticipated from future solar and, to a lesser extent, wind farms. In this respect, a significant reduction in output from a wind or solar farm over a short period of time has a similar effect on frequency (and therefore frequency control) as the trip of a similarly sized synchronous generator, albeit over longer period of time. Analysis has shown that events would vary in size, with the probability of occurrence decreasing for larger events. As an example, one of the existing major solar farms in the NEM has been observed to experience a handful of events each month where movement over four seconds was between 20% and 50% of rated capacity, but only up to one event per month where movement exceeded 50% of rated capacity. In complying with the current FOS, AEMO would be obliged to contain these types of events within the Normal Operating Frequency Band, which would potentially require increased volumes of regulation FCAS. This could carry significant cost and may not be efficient. In preparing this advice, AEMO has not had sufficient time to estimate the potential quantity and cost of such additional FCAS.

It must also be recognised that no level of regulation service is capable of dealing with all events, which is why the contingency services exist. That is, depending on the size and rapidity of the event, it may not even be physically possible to cater for these events with regulation FCAS, as it is a slower responding service than some forms of contingency FCAS.

The scale in MW for any sudden variation of generation output is currently 50 MW for a connection or disconnection of a single generating unit. AEMO considers that the current size of 50 MW is workable and has not identified any reason to vary from this. However, it is quite conceivable that depending on how the NEM develops over the next few years, this threshold may need to be re-evaluated. For instance, if many solar or wind farms of less than 50 MW were built, rather than a few of larger sizes (say 200 MW) then the magnitude and frequency of rapid changes in output around the 50 MW threshold is likely to be significantly different. This would require detailed review, assessing the likelihood and probable size of potential changes in generation. In summary, AEMO suggests that the 50 MW value should be periodically reviewed to assess its ongoing appropriateness.

Similarly, the time period over which a sudden variation of generation output is measured requires consideration. For example, at least a 50 MW change within a one minute time period. AEMO's view is that the current definition of a generation event clearly contemplates that the 50 MW change is very rapid, since it refers to tripping or connection situations. To meet with the obligations of the FOS, these generation events should be dealt with by contingency FCAS rather than regulation FCAS. In fact, under current market frameworks, contingency FCAS is the only market service that is able to deal with very rapid and significant changes. Regulation FCAS is only able to respond to frequency deviation over a significantly longer timeframe; approximately 30 seconds compared with contingency FCAS which can respond in a handful of seconds (the fastest service is the six second service). Therefore AEMO considers that time period associated with a generation event should be dictated by the capability of different services to manage these events, assuming the services are not fundamentally changed, which is outside the scope of the FOS. As it is intended that the revised definition of generation event would mean that regulation FCAS is

not expected to be able to deal with these events, the appropriate timeframe would be less than or equal to 30 seconds, which is an approximate response time of the regulation FCAS service (implemented through AGC).

Reference to generating unit

AEMO has been asked whether the reference to a generating unit in relation to the definition of generation event is still appropriate or whether the definition of a generation event refer to an alternative term such as generating system.

The reference to a 'generating unit' is no longer appropriate, as this fails to recognise the nature of variable generators. It is not even clear what a 'unit' would be exactly in a solar farm or wind farm. The term 'generating system' is more appropriate, but still does not capture the potential for multiple generation systems in close physical proximity, which could be affected by local unexpected events such as cloud cover or a cold or warm front affecting wind speeds.

Proposed approach

To properly capture the kinds of events anticipated (and other possible future events), AEMO proposes the FOS clearly map the definition of generation events to credible contingency generator events as defined in the NER, which provides for AEMO to define credible contingency events under clause 4.2.3.

To provide this linkage, generation events in the FOS could be defined, for example, as "*a rapid, unforeseen increase or decrease in the real power injection to the power system from one or more generating units, consistent with what AEMO considers to be a credible contingency event under clause 4.2.3 of the NER*".

Overall AEMO considers that this approach allows for greater adaptability as the need arises and avoids the need to continually review the appropriateness of the FOS definition as the NEM evolves. AEMO believes that this type of generation event is covered within clause 4.2.3:

> 4.2.3 Credible and non-credible contingency events
>
> (a) A contingency event means an event affecting the power system which AEMO expects would be likely to involve the failure or removal from operational service of one or more generating units and/or transmission elements.
>
> (b) A credible contingency event means a contingency event the occurrence of which AEMO considers to be reasonably possible in the surrounding circumstances including the technical envelope. Without limitation, examples of credible contingency events are likely to include:
>
> > (1) the unexpected automatic or manual disconnection of, or the unplanned reduction in capacity of, one operating generating unit; or
> >
> > (2) the unexpected disconnection of one major item of transmission plant (e.g. transmission line, transformer or reactive plant) other than as a result of a three phase electrical fault anywhere on the power system.

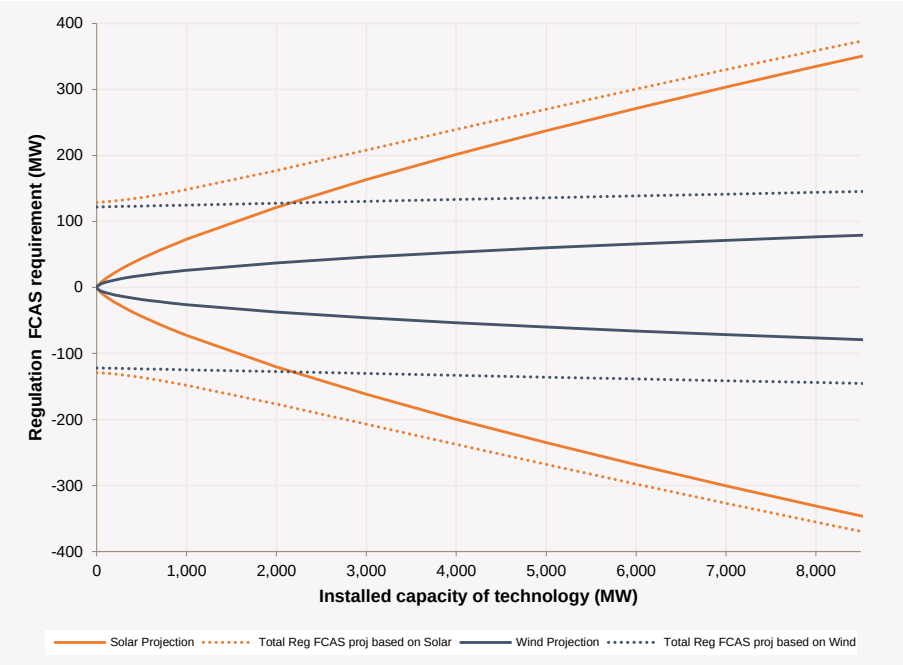
Clause 4.2.3(a) sets out the likely cause of events, including the failure of one or more generating units. Generation ramping from variable generators can be considered as a failure of their fuel source and arguably fit within this definition. Clause 4.2.3(b) lists, without limitation, examples of credible contingency events which include the unplanned reduction in capacity. Therefore, by way of example, if AEMO considers it "reasonably possible" that a

group of windfarms in South Australia will change their output by say 50% in 30 seconds, then this may be treated as a credible contingency event under clause 4.2.3(b) after going through due process. The due process would involve tested metrics and a monitoring process for making these declarations; a process that would need to be done no matter what mechanism is used to make the declarations. Such credible generation events may only occur once or twice a year, which is similar in probability to the trip of a synchronous unit.

If generation events are linked to credible contingency events, it will assist AEMO perform its function as the power system operator as it will:

- Align AEMO's obligations more closely with the physical realities of available services.
- Help to minimise FCAS procurement.
- Provide a technology-neutral approach to implementing the FOS by removing the implication that generation events apply only to single synchronous plants but not to equivalent effects of multiple non-synchronous plants.
- Allow flexibility to respond to the changing nature of generation events.

If this change is not made, AEMO may be required to purchase additional regulation FCAS in order to meet the FOS. Specifically, AEMO would be obligated to try and maintain frequency in the normal operating frequency band for these events. As variable generators are built in increasing number and size, this will increase the overall frequency and magnitude of events involving significant and rapid changes in output. This will drive up the amount of regulation FCAS required to attempt to deal with these events. AEMO's analysis suggests that utility-scale PV variability is especially significant, and likely to lead to a significant increase in regulation FCAS required once 1-2 GW are installed. This is expected as early as mid-2018. The figure below draws from this analysis. Note that this projection is highly indicative due to data limitations and it assumes no systematic improvement in solar farm behaviour or forecasting capabilities. It is based on projected movements on the 5-min scale, rather than shorter time scales, but illustrates the effect of increased intermittency on regulation services:



If the proposed changes to the definition of generation events is implemented, future FCAS procurement will be minimised, as the types of events contemplated by this change could be dealt with using the existing levels of contingency FCAS. Since contingency FCAS procurement is based upon the largest credible contingency, and rapid changes in output from variable generation sources are unlikely to constitute a larger credible contingency, the total amount of contingency FCAS procured would not change. For example, the largest credible generation contingency in the NEM is frequently the loss of the Kogan Creek unit, which is some 740 MW. This is much larger than any potential variable generation event likely in the near term, though it is possible that in the future, extremely large variable generators (or groups of variable generators that are located very close together) could potentially be subject to events larger than the loss of current large generating units. In any case, contingency FCAS, rather than regulation FCAS, is the only service capable of managing such large and rapid events, which indicates the importance of this change in definition for generation events. For completeness, AEMO notes that with the proposed change, it is possible that there may be an increase in the frequency of use of contingency FCAS, which could conceivably result in providers eventually changing bids to compensate for additional wear and tear. However it is expected that this would be minor compared with the cost of additional regulation FCAS procurement.

AEMO regards that this is an important change, as these kinds of generation events are already occurring, and are anticipated to become larger and more frequent as committed solar farms are commissioned. Some of these may be in service by summer of 2017-18. Therefore AEMO regards that it is important to implement changes to recognise these events in the same manner as existing generation events prior to the upcoming summer.

Other matters AEMO wishes to bring to the Panel's attention

FOS structure and consistency.

AEMO requests that the Panel review the structure of the FOS and its usage of terminology to improve its legal robustness and to minimise the potential for different interpretations by AEMO and other stakeholders. Specifically, the split between Parts A, B, C and D of the FOS makes for difficult reading, as the purpose and scope of each part is not necessarily intuitive. Furthermore, there are instances where terminology is not used consistently throughout the FOS. As an example, these two issues can be shown by how 'supply scarcity' provisions are incorporated in the FOS. Part A, which is designated as a summary, actually contains information on supply scarcity that is not found in the other Parts, which should provide all the detail supporting the Summary (Part A). The supply scarcity provisions also use inconsistent terminology; it appears that Part B instead refers to 'load restoration' in place of 'supply scarcity'.

This overlap between sections and inconsistent use of terminology make interpreting AEMO's obligations more difficult and perhaps leaves some situations ambiguously defined. AEMO proposes to document each matter where the FOS would benefit from clarification and provide these details to the Panel separately via the AEMC and work collaboratively towards an improved FOS. As this could lead to substantial re-drafting of the FOS, it is proposed that this be dealt with over the Stage 2 timeframe.

Attachment 2: Request for advice

Scope of AEMO advice

As per NER clause 8.8.1(a)(2) the Panel is responsible to, "review and, on the advice of AEMO, determine the power system security standards". Therefore to inform and support the Panels determination of the FOS, we request that AEMO provide formal advice covering the following:

1) Inclusion of a standard to apply to protected events

AEMO is requested to provide advice to inform the Panel's determination of the components of the FOS. To inform the Panel's decision, AEMO is asked to:

a. Recommend what frequency bands should apply for protected events in the NEM mainland and for Tasmania.
b. Recommended what stabilisation and restoration bands and timeframes should apply following protected events in the NEM mainland and Tasmania.
c. Describe any other considerations that the Panel should be aware of in relation to the inclusion of a standard for protected events in the FOS.
d. Describe AEMO's preferred time frame and comment on the criticality for the implementation of a revised FOS that incorporates a standard for protected events.

In making these recommendations, AEMO should refer to the existing interim frequency operating standard for protected events, set out in NER clause 11.97.2, and provide a clear explanation as to why any changes may be required from the interim standard.

2) Amendments to the requirements for multiple contingency events

The Panel is proposing to revise the requirements in the FOS for multiple contingency events as per the following:

> "as a result of any multiple contingency event, AEMO should use its best endeavours to:
>
> i. maintain system frequency within the *extreme frequency excursion tolerance limits* and
>
> ii. avoid the system frequency exceeding the applicable generation and load change band for more than two minutes while there is no contingency event or exceed the applicable *normal operating frequency band* for more than ten minutes while there is no contingency event."

In relation to this issue:

a. Does AEMO support this proposed revision of the FOS in relation to multiple contingency events? Does AEMO have any suggested modifications to this wording?
b. What is AEMO's preferred time frame and comment on the criticality for the implementation of a revised FOS that reflects this approach to multiple contingency events?

3) The inclusion of guidance for the characteristics of an 'electrical island'

The suggested approach to this issue is to revise the definition of an electrical island in the FOS to:

> "*electrical island* means a part of the *power system* that includes *generation*, *networks* and *load*, for which all of its network connections with other parts of the *power system* have been disconnected, provided that the part:
>
> (a) does not include more than half of the *generation* of each of two *regions* (determined by available capacity before disconnection); and
>
> (b) is at least equal to or greater than an *inertia sub-network*."

This definition of inertia sub-network will be added to the definitions in the FOS:

> "*inertia sub-network* has the meaning given to it in the rules."

In relation to this issue:

a. Does AEMO support the proposed revision of the definition of an electrical island in the FOS? Does AEMO have any suggested modifications to this wording?
b. What is the preferred time frame and comment on the criticality for the implementation of any change to the definition of an electrical island in the FOS?

4) Review of the requirement for accumulated time error in the FOS

AEMO is requested to provide advice:

a. quantifying the historical cost of time error correction in the NEM for the mainland and for Tasmania.
b. identify whether there any system security benefits currently provided by the requirement for AEMO to undertake accumulated time error correction
c. describing the costs and implications, for AEMO systems, of removing or relaxing the requirement for a limit on accumulated time error in the FOS.
d. Describing any operational and system security benefits that may be realised through the relaxation or removal of the requirement to limit accumulated time error.
e. As to whether, to AEMO's knowledge there are any critical processes or equipment that would be adversely impacted by the removal or relaxation of the requirement to limit accumulated time error.
f. As to whether or not AEMO is supportive of the removal or relaxation of the requirement to limit accumulated time error.
g. As to the preferred time frame and comment on the criticality for the implementation of any change to the requirement to limit accumulated time error.

5) Review of the definition of terms in the FOS, (definition of a generation event)

The issues paper for the review of the FOS discussed a potential revision to the definition of the term "generation event" in the FOS; that this definition is expanded to include the sudden and unexpected variation of generation output. In relation to this definition in the FOS:

a. What is the basis for AEMO requesting the revision of the definition of generation event in the FOS?
b. Please confirm the technical parameters that AEMO advise are appropriate for the definition of such an event, including:
    a. The scale in MW for any sudden variation of generation output (currently 50MW for a connection or disconnection of a single generating unit)
    b. The time period over which a sudden variation of generation output is measured, ie at least a 50MW change within a 1min time period.
    c. Is the reference to a generating unit in relation to the definition of generation event still appropriate, or should the definition of a generation event refer to an alternative term such as generating system?
c. How will these changes help AEMO perform its function as the power system operator?
d. What is AEMO's preferred time frame and comment on the criticality for the implementation of this change to the definition of generation event in the FOS?