1 August 2017

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Dear Mr Henderson

Review of the Frequency Operating Standard: Issues Paper

The Australian Energy Market Operator (AEMO) welcomes the opportunity to contribute to the Reliability Panel's (Panel) review of the Frequency Operating Standard (Standard, or FOS).

Triggered by the need to incorporate Protected Events into the Standard as a result of recent rule changes[1], the Review provides an opportunity to clarify ambiguities that AEMO believes currently exist within the Standard.

Protected events are a new classification of specific non-credible contingency events that will place certain obligations on AEMO to manage system frequency for their occurrence. They differ from non-credible contingency events as they provide AEMO with the ability to undertake more pre-emptive action. As such, it is important in the long term that these are explicitly incorporated in the FOS so that they can be managed alongside other contingency events.

The FOS underpins power system operation, as it sets out the frequency bands within which AEMO must seek to operate the system under a range of conditions. It influences, amongst other things:

- The amount and types of Frequency Control Ancillary Services (FCAS) that AEMO procures.
- The design of systems such as the Automatic Generation Control (AGC) which is utilised to operate the grid in line with the FOS.
- The nature of technical standards for generation and network equipment.
- The design and operation of emergency frequency control schemes such as under frequency load shedding (UFLS) and other protection mechanisms.

The energy market is undergoing a transformation, and it is therefore critical that the FOS provides the necessary clarity for AEMO, prospective FCAS providers and other stakeholders. In this respect, the Review should also be used as an opportunity to address issues relating to definitions in the Standard. AEMO has identified the terminology related to

[1] http://www.aemc.gov.au/Rule-Changes/Emergency-frequency-control-schemes-for-excess-gen#

multiple contingencies, generation events and electrical islands as benefiting from clarification.

These matters are expected to be relatively straightforward to address without interfering with other elements of the FOS. Other issues raised by the Panel, such as the appropriateness of the various frequency bands, are more complex and depend on other considerations that are broader than the FOS. The staged approach proposed by the Panel will allow these independent more straightforward issues to be addressed in Stage 1. The subsequent stage of the review can then benefit from other streams of work that are underway by the Australian Energy Market Commission (AEMC), AEMO and industry.

If you would like to discuss this submission further, please contact Alison Demaria, Manager Future Grid Development via alison.demaria@aemo.com.au.

Yours sincerely

Cameron Parrotte
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Attachments: AEMO submission – Frequency Operating Standard Issues Paper

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Background

AEMO is the independent market and power system operator of the National Electricity Market (NEM) in eastern Australia, and the South West interconnected system (SWIS) in Western Australia. AEMO also operates wholesale gas markets in the eastern States.

In this context, AEMO is responsible for the secure operation of the interconnected power system, and is currently undertaking a broad program of work to assess and address the technical challenges that are likely to emerge as the generation mix in the NEM continues to change. A key component of this work relates to frequency control, and AEMO's submission draws upon this analysis.

Frequency is a core metric of the stability of the power system, representing the supply-demand balance at any instant. If demand is greater than supply the frequency falls from the nominal 50 Hz, and vice versa if supply exceeds demand. Equipment connected to the system is designed to operate at this frequency and whilst can operate outside these bands can only do so for certain scale of deviation and duration without impacting efficiency or potentially damaging plant. The FOS specifies the bounds within which AEMO must manage the power system frequency with different obligations for normal operating conditions, and credible and non-credible contingency events. The definitions of credible and non-credible events are set out in the National Electricity Rules (NER).

Subsequently, operational decisions, tools and standards are derived with the FOS in mind, including:

- The amount and types of Frequency Control Ancillary Services (FCAS) that AEMO procures.
- The design of systems such as the Automatic Generation Control (AGC) which is utilised to operate the grid in line with the FOS.
- The nature of technical standards for generation and network equipment.
- The design and operation of emergency frequency control schemes such as under frequency load shedding (UFLS) and other protection mechanisms.

These dependencies mean that any major changes to the FOS can't be performed in isolation of frequency control mechanisms more broadly, and it is important not to have ambiguity.

Approach to the FOS Review

The Panel has proposed a two-stage approach to the FOS review which allows immediate concerns to be progressed while allowing more complicated, longer-term matters to be informed by analysis underway by AEMO, the AEMC and industry.

Stage 1 considers:

- Changes to the FOS to explicitly accommodate protected events.
- Other changes to the FOS that can be assessed immediately, and have no follow-on effects.

Stage 2 considers the settings of the frequency bands and parameters for maintenance and restoration of system frequency following a disturbance. Stage 2 needs to consider how any

fundamental changes to the FOS might affect the spectrum of frequency control mechanisms required today but also in the future. Furthermore, this will need to be co-ordinated with frequency control considerations that are currently underway including:

- Assessment of frequency control performance, examining the observed decline in how tightly frequency is bound around 50 Hz. This work is analysing changing levels of governor response in the NEM and other factors that may be involved such as the configuration of the AGC control systems AEMO uses to send dispatch instructions to help arrest and stabilise a frequency deviation. AEMO is progressing this work in consultation with the Ancillary Services Technical Advisory Group (AS-TAG), an industry group.
- The AEMC and AEMO are progressing work on power system inertia requirements as part of the Rule Change *Managing the rate of change of power system frequency*[2]. On 27 June 2017, the AEMC published a draft rule to place an obligation on Transmission Network Service Providers (TNSPs) to procure minimum required levels of inertia or alternative frequency control services to meet these minimum levels. The level of inertia in a system affects how quickly frequency disturbances are arrested.
- Investigation of potential Fast Frequency Response (FFR) services, which can provide an alternative to the governor response which synchronous generators can provide, as well as opportunities to complement other frequency control mechanisms.

These matters are likely to be under the umbrella of the AEMC's recently announced Frequency Control Frameworks Review[3] , and were also raised in the Independent Review into the Future of the NEM (Finkel Review)[4]. Outcomes of these matters will be important for the Panel to take into consideration when evaluating some of the settings in the FOS, and in particular the appropriateness of the frequency bands.

Particular matters raised in the FOS Issues Paper

AEMO considers the following areas should be addressed in Stage 1 of the FOS Review as they are in line with the Reliability Panel's objectives for Stage 1:

- Multiple contingencies and incorporation of Protected Events.
- Definition of electrical islands.
- Definition of generation events.
- Time Error Correction; at least in terms of investigation and analysis. Stakeholder engagement and consultation on implementation may not be possible in the Stage 1 timeframe.

Multiple contingencies and incorporation of Protected Events

At present, part B(f) of the FOS expresses obligations to manage frequency for multiple contingencies in absolute terms: '*as a result of any multiple contingency event, system frequency should not exceed the extreme frequency excursion tolerance limits*'.

[2] http://www.aemc.gov.au/Rule-Changes/Managing-the-rate-of-change-of-power-system-freque
[3] http://www.aemc.gov.au/Markets-Reviews-Advice/Frequency-control-frameworks-review
[4] http://www.environment.gov.au/system/files/resources/1d6b0464-6162-4223-ac08-3395a6b1c7fa/files/electricity-market-review-final-report.pdf

It is not practical to manage frequency for all possible multiple contingencies, since these may span anything from the simultaneous failure of a generating unit and a minor transmission line - which may be survivable - through to the simultaneous failure of all units at multiple large power stations – a situation which is unlikely to be survivable. The principle underlying the NER system security rules is that AEMO will implement all reasonable advance measures for the system to continue to operate within the applicable standards following a credible contingency event, but is not expected to pre-emptively secure the system against non-credible or multiple contingencies.

Replacing this multiple contingency obligation with an obligation to manage frequency for Protected Events should resolve the issue, given that protected events are defined as non-credible contingencies (which may include multiple contingencies) which are specifically identified as high impact, low probability events. AEMO considers the interim frequency standard settings as set out in the final Protected Events rule determination as workable and has not identified any reason to vary from them.

Definition of electrical islands

The FOS currently does not explicitly provide a definition of an electrical island for which the Standard is to apply. This should be made clear and also be consistent with other definitions within the NER. The AEMC's recent draft determination on managing high rates of change of frequency provides a suitable reference point for this assessment. The draft determination stipulates that AEMO must determine boundaries of sub-networks (referred to as 'inertia sub-networks') that are at risk of islanding and which should be able to be maintained in a satisfactory and then secure state if islanding occurs.

The FOS needs to be consistent with these definitions of sub-networks as they both relate to the procurement of frequency control services to manage power system security. Importantly, if the FOS and inertia electrical islands are not directly related:

- The FOS sub-networks may not have sufficient inertia or primary frequency response to manage power system security.
- There would be implications for FCAS procurement in these sub-networks. AEMO would need to determine how much FCAS is required to satisfy the security obligations for each prospective network island, and then procure sufficient FCAS. It is noted that small sub-networks may also have limited providers which could be an issue for market competition. As the level of inertia in the sub-network would affect the amount of FCAS required, procuring services across two separate sub-networks would be inefficient.
- There may be challenges in delivering frequency control in sub-networks if they are defined without consideration of AEMO's systems (such as AGC) which have practical limits on how many sub-networks can be controlled and where. This would be circumvented if the definition applicable to inertia is accepted because AEMO will be in a position to co-ordinate AGC capability with sub-network declarations.

AEMO notes that the System Restart Standard (SRS) also provides a definition of electrical sub-networks. In this case, the electrical sub-network should be capable of being maintained in a satisfactory operating state to the extent practicable during the restoration process, whereas the inertia sub-networks apply for secure operating conditions. Further thought is required to determine whether the sub-networks for SRS should be defined separately to the electrical islands in the FOS.

Definition of generation events

AEMO requests the Panel to revise the definition of *generation events* which are described in terms of [*the 'synchronisation' of a generating unit or a credible generation contingency*]. Two aspects need addressing:

- The reference to synchronisation is confusing and limited, and does not reflect the generation mix.
- A credible contingency (for generating units) is defined in the NER as '*the unexpected automatic or manual disconnection of, or the unplanned reduction in capacity of, one operating generating unit*'.

These do not satisfactorily describe all kinds of rapid, unexpected generation events. As the generation mix evolves to one of more intermittent 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[5]. 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 a slightly longer period of time.

It is more appropriate to define a generation event as a large rapid unexpected change in generation output from a generator or set of generators resulting from a common event. AEMO has identified two immediate options to address this:

- The FOS could be updated to explicitly cater for these generation events. While this would set clear requirements to manage the specified events, this clarity is at the expense of a lack of flexibility to adapt to the changing nature of generation events over time.
- The definition of a generation event could be more clearly mapped to a credible generator contingency event as set out in the NER, which provides for AEMO to refine credible contingency events under Clause 4.2.3 to allow reasonably possible generation events to be declared credible. This approach allows for greater adaptability as the need arises.

AEMO considers the second option preferable as it allows it to adapt to the changing operating environment within the NER framework, with the Standard as a backdrop. As the energy market transforms, it is likely that AEMO will need to deal with different types of generation events, and the flexibility of this approach will more efficiently facilitate the management of power system security.

Regardless of the approach, at a minimum the Panel should rectify the currently opaque definition of a generation event in the FOS.

Time Error Correction

Assessing the need for Time Error Correction (TEC) is appropriate, and ties in to AEMO's ongoing work on frequency control performance and governor response with the AS-TAG. TEC can impact frequency control because of the need to contain the accumulated time error within the Standard.

[5] AEMO. *Projection of regulation FCAS needs*. Internal analysis.

AEMO also procures additional regulation FCAS at times to help contain accumulated time error. This can have a material impact on FCAS market prices, as demonstrated on 26 March 2017. Due to time error requirements, raise regulation FCAS requirements for the mainland NEM increased from 130 MW to 247 MW, and associated prices reached $472.66/MWh for the trading interval[6].

AEMO notes that the Panel will consult with consumers regarding the importance of TEC which is appropriate and valuable. AEMO is not aware of any specific impacts, or complaints made to AEMO about:

- Its time-keeping performance in general.
- In relation to re-setting of accumulated time error, which is necessary when systems that have been islanded are connected back to the rest of the system[7].

AEMO is well placed to provide input to assist the Panel's assessment of matters such as:

- Whether TEC is causing issues for customers and market participants and if so, what exactly those issues are and how impactful. This may include issues such as potentially undesirable interaction with frequency response of AEMO systems and distortion of FCAS causer-pays factors. AEMO notes that negative impacts of conducting TEC may be partially mitigated via means such as:
    - A relaxation of the time-error standard (e.g. relaxing the 5-second maximum time error to say 15-seconds, which is the Tasmanian standard). The costs and benefits of a more relaxed standard would need to be investigated.
    - Undertaking TEC during optimal periods rather than in a continuous fashion as is currently done via the AGC system. This could potentially be done during periods where frequency control is expected to be less onerous.
    - AEMO being provided the scope to prioritise frequency control over TEC; in effect, allow the time standard to be loosened if justified. This may involve the power to explicitly reset Time Error to zero following significant system events. AEMO notes that resetting the time error in an islanded system is already something that must be done when islands are reconnected.
- An assessment of systems changes and what costs and savings AEMO may incur if TEC was removed or modified. This may include:
    - Modifications to the AGC system and other impacted systems (cost).
    - Reformulation of regulation FCAS constraints (cost).
    - Elimination of FCAS regulation purchases related to TEC (saving).
    - Potentially improved frequency regulation (saving).
- What external procedures may need to change as a result of discontinuing or relaxing TEC and the time and resources required to make these changes.

[6] http://www.aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Pricing-Event-Reports/Mar-2017/26-March-2017---High-FCAS-price-Mainland.pdf

[7] Islanded systems will have their own frequency control and thus their own time error. Once re-connected, only one frequency control and thus one time error may apply.

Summary

AEMO supports the Panel's staging of the Review through an initial stage of clarifying the existing framework, and a longer term consideration of the FOS in context of future frequency control frameworks.

The first stage provides an opportunity to clarify existing frameworks, specifically:

- Incorporation of protected events and assessment of the definition of multiple contingencies with consideration of explicitly defining multiple contingencies as protected events. AEMO considers the interim frequency ranges as set out in the Protected Events final rule determination as workable and has not identified any reason to vary from them.
- The definition of electrical islands, and consideration of the relationship with inertia sub-networks defined by the AEMC, in particular AEMO's role in defining the islands.
- Update the definition of generation events in the FOS and consider how best to capture rapid, unexpected changes in generation from intermittent sources preferably by directly mapping them to credible contingency events in the NER.
- The merit of exploring the relevance of TEC in future frequency control.