RELIABILITY PANEL AEMC

PANEL DETERMINATION

Reliability Panel AEMC

# STAGE ONE FINAL DETERMINATION

## Review of the frequency operating standard

14 November 2017

Reference: REL0065: Determination

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**About the Reliability Panel**

The Panel is a specialist body within the Australian Energy Market Commission (AEMC) and comprises industry and consumer representatives. It is responsible for monitoring, reviewing and reporting on reliability, security and safety on the national electricity system, and advising the AEMC in respect of such matters. The Panel's responsibilities are specified in section 38 of the National Electricity Law.

# Executive Summary

The Reliability Panel (Panel) has prepared this determination for stage one of the frequency operating standard (FOS) Review 2017.

Under the National Electricity Rules (NER), the Reliability Panel (Panel) is responsible for determining the power system security standards, including the frequency operating standards (FOS) that apply to the National Electricity Market (NEM).

*What is the FOS?*

The FOS include defined frequency bands and timeframes in which the system frequency must be restored following different events, such as the failure of a transmission line or separation of a region from the rest of the NEM. These requirements then inform how AEMO operates the power system, including through applying constraints to the dispatch of generation or procuring ancillary services.

The FOS does not set out the specific arrangements for how frequency is managed, such as the arrangements for generation and load shedding and the specification and procurement of Frequency Control Ancillary Services (FCAS).

*The review of the FOS*

The Reliability Panel (Panel) is undertaking a review of the FOS that applies for Tasmania and for the mainland NEM. The Panel is proposing to complete this review in two stages. This staged approach reflects the various ongoing reviews of market and regulatory arrangements that are likely to have an impact on the Panel's ability to effectively assess the FOS.

In particular, the Panel recognises the interactions between this review and the AEMC's *Frequency control frameworks review* which will consider the market frameworks necessary to support better frequency control in the NEM. On 7 November 2017, the Commission published an issues paper for the *Frequency control frameworks review,* which set out the scope of the review. This scope includes consideration of potential mechanisms for provision of sufficient primary frequency control to support frequency regulation during normal operation and whether the existing FCAS market arrangements in the NER are fit for purpose.

This determination sets out the Panel's considerations in relation to the FOS for stage one of the review which addresses changes to the FOS that relate to the implementation of the *Emergency frequency control schemes* rule and other isolated issues.

Stage two of the review will include a general consideration of the various components of the FOS, including the settings of the frequency bands and time requirements for maintenance and restoration of system frequency. The Panel recognises that the outcomes of the *Frequency control frameworks review,* in relation to primary frequency control and FCAS markets, may have direct and indirect impacts on the subsequent assessment of the frequency bands in the FOS. Therefore the Panel will commence stage two of this review when the AEMC *Frequency control frameworks review* is further progressed.

*The FOS for stage one of the review*

Following completion of stage one of the review, the Panel has made a new FOS for Tasmania and for the mainland. This FOS differs from the previous FOS in a number of key ways:

- The inclusion of a standard for protected events in the FOS. This is the same as the interim standard that was applied for protected events following the Emergency frequency control schemes rule change. The FOS states that following a protected event, the frequency should remain within the emergency frequency excursion tolerance limits.
- The revision of the requirements in the FOS in relation to multiple contingency events. The FOS requires that AEMO use reasonable endeavours to stabilise and restore the power system following non-credible contingency events and multiple contingency events that are not protected events.

  AEMO's submission to the Draft Determination indicated support for the removal of the multiple contingency requirement from the FOS: arguing that the requirement set out in the Draft FOS introduced a potentially ambiguous conflict with the system security obligations set out in the NER. On the other hand submissions from the ENA, Origin Energy and Meridian Energy expressed support for the multiple contingency requirement set out in the Draft FOS.

  The Panel considers that the multiple contingency requirement in the FOS provides a clear target for the coordination of emergency frequency control schemes and aligns the expectations for managing multiple contingency events with the existing generator technical performance standards for response to frequency disturbances. Furthermore this change recognises that it is not possible to maintain secure operation of the power system for all potential multiple contingency events.
- The revision of the definition of 'generation event' to include the sudden, unexpected and significant change in output from one or more generating systems of 50MW or more within a 30 second period.

  CS Energy's submission to the Draft Determination presented the case that this change was not warranted as the large sudden variations of generation output from variable renewable power station is very rare and can be managed through improvements to AEMO's automatic generation control (AGC) system which controls the operation of regulating FCAS.

  The Panel understands that significant, sudden and unexpected variations in the supply demand balance require a rapid balancing response. Under the current frequency control frameworks this rapid response is provided by contingency FCAS. Therefore, it is appropriate at this time for the definition of generation event to cover an event that results in a significant, sudden and unexpected variation of generation output from one or more generating systems to allow these event to be managed with contingency FCAS.

The broader issues raised by CS energy with respect to frequency control during normal operation are being considered by the AEMC through the *Frequency control frameworks review.*

This revision is being made to clarify that it is appropriate for contingency FCAS to be used to manage sudden variations of generation output from the increasing quantity of larger variable renewable generation power stations. Under the current regulatory framework the Panel considers that it is more appropriate for these types of variation of generation output to be managed with contingency FCAS as compared to regulating FCAS. This change is expected to result in lower FCAS costs over the short term than would otherwise be the case.

- The revision of the definition of an island for the purpose of application of the FOS for island operation following a separation event.

  This revised definition maintains the key elements of the existing definition of an island with the addition of a new requirement, that an island must be at least the equal to or greater than an inertia sub-network.

- The increase of the limit for accumulated time error that applies for the mainland from 5 seconds to 15 seconds. The limit of accumulated time error in the FOS for Tasmania remains unchanged at 15 seconds.

  The Panel's initial consideration is that there may be a case for the complete removal of the accumulated time error limit. However, there is some possibility that the removal of this time error limit could have unforeseen impacts on large and small consumers. In order to limit the risk, the Panel has decided to initially relax the accumulated time error limit, with a view to the potential for full removal, once consultation has been undertaken with a wider range of consumers.

  The Panel will continue to consult with stakeholders in relation to the potential removal of the accumulated time error limit from the FOS through the course of stage two of this review.

*Stage two of the review will commence when the Frequency control frameworks review is further progressed*

During stage two of the Review, the Panel will conduct a thorough review of the settings of the FOS, including examining the boundaries of the various frequency bands and the timeframes for restoration of power system frequency following specific events.

In recognition of the interactions between this review and the *Frequency control frameworks review*, the Panel will commence stage two of this review when the AEMC *Frequency control frameworks review* is further progressed.

## Reliability Panel members

Neville Henderson, Chairman and AEMC Commissioner

Trevor Armstrong, Chief Operating Officer, Ausgrid

Lance Balcombe, Chief Executive Officer, TasNetworks

Cameron Parrotte, Executive General Manager, Strategy & Innovation, AEMO

Mark Collette, Executive Energy, EnergyAustralia

Royce De Sousa, General Manager - Energy & Sustainability, Visy

Gavin Dufty, Manager Policy and Research, St Vincent de Paul Society, Victoria

Miles George, Strategic Adviser, Infigen Energy Ltd

Chris Murphy, Strategic Advisor, Meridian Energy and General Manager – Energy Market Interfaces, Telstra

Richard Wrightson, Executive General Manager, Wholesale Markets, AGL Energy

# Contents

# 1 Introduction

The Reliability Panel has been directed by the Australian Energy Market Commission to undertake a review of the frequency operating standards (FOS) that apply for the NEM mainland and for Tasmania in accordance with its responsibilities under the National Electricity Rules (Rules).[1]

The Panel's considerations for the determination of the stage one FOS are set out in this report.

## 1.1 Review of the FOS

NER clause 8.8.1(a)(2) requires the Reliability Panel to review and, on the advice of the Australian Energy Market Operator (AEMO), determine the power system security standards. These standards govern the maintenance of system security and reliability in the NEM; at present the only power system security standards that apply in the NEM are the FOS for the mainland NEM and for Tasmania. The FOS define the range of allowable frequency for the power system under different conditions, including normal operation and following contingency events.

The FOS include defined frequency bands and timeframes in which the system frequency must be restored following different events, such as the failure of a transmission line or separation of a region from the rest of the NEM. These requirements then inform how AEMO operates the power system, including through applying constraints to the dispatch of generation or procuring ancillary services.

The FOS also defines the frequency bands and timeframes which are referred to by the performance standards that apply to generator and network equipment in the NEM. In combination with the FOS, these performance standards align the power system frequency managed by AEMO with the capability of NEM power system equipment, including generating and network systems.

The FOS does not set out the specific arrangements for how frequency is managed, such as the arrangements for generation and load shedding and the specification and procurement of Frequency Control Ancillary Services (FCAS).

## 1.2 Terms of reference

On 30 March 2017, the Australian Energy Market Commission (AEMC) provided Terms of Reference to the Panel to initiate a review of the FOS (the Review).

Among other things, the Terms of Reference require the Panel to give consideration to:

- Whether the terminology, standards and settings in the FOS remain appropriate.
- What amendments to the Standard may be necessary in light of the AEMC's final determination of the Emergency Frequency Control Schemes rule change published on 30 March 2017.
- Whether further guidance can be provided regarding the definition of what part of the power system the FOS is to be applied following separation from the rest

1 Clause 8.8.1(a)(2) of the NER.

of the NEM. Specifically, whether the FOS should refer to a separated region, or some smaller subsection of a region, for the maintenance of frequency following a separation event.

On 12 September 2017 the Commission issued revised terms of reference for the review to accommodate the Panel's proposed staged approach. The revised terms of reference require the Review to be completed by 31 July 2018 in line with recommendation 2.3 from the Finkel Panel report.[2] Recommendation 2.3 from the Finkel Panel report, recommended that by mid-2018, the Australian Energy Market Operator and Australian Energy Market Commission should:[3]

- Investigate and decide on a requirement for all synchronous generators to change their governor settings to provide a more continuous control of frequency with a deadband similar to comparable international jurisdictions.
- Consider the costs and benefits of tightening the frequency operating standard.

These issues are discussed in section 5.1.2.

The revised terms of reference for this Review can be seen in Appendix A.

## 1.3 Timetable for the Review

In carrying out this review, the Panel will follow a consultation process that is consistent with clause 8.8.3 of the NER and the Terms of Reference. The Panel consulted with stakeholders through seeking submissions to the issues paper and stage one draft determination and will invite stakeholder submissions to the subsequent draft determination for stage two of the review. The Panel will also carry out face to face meetings and a public forum may be arranged as required at the request of stakeholders.

The Panel is undertaking this review in a staged manner. The two stages of the review will be commenced at different times and will cover different subject matter. This staged approach reflects the various ongoing reviews of market and regulatory arrangements that are likely to have an impact on the Panel's ability to effectively assess the FOS.

Stage one of the Review is now complete and has considered amendments to the FOS in light of the recent *Emergency frequency control scheme rule change*, which includes the introduction of the protected event contingency category made in the recent emergency frequency control schemes rule change.[4] Furthermore, there are a number of technical changes to the FOS that have been addressed through stage one of the review.

Stage two of the Review will include a general consideration of the various components of the FOS, including the settings of the frequency bands and time requirements for

2 Finkel Panel, June 2017, *Independent Review into the Future Security of the National Electricity Market – Blueprint for the Future, pp.21,61.*

3 Finkel Panel, June 2017, *Independent Review into the Future Security of the National Electricity Market – Blueprint for the Future, pp.21,61.*

4 AEMC, Emergency frequency control schemes, Rule Determination, 30 March 2017.

maintenance and restoration of system frequency. Stage two will commence following further progression of the AEMC *Frequency control frameworks review*, which is considering whether the arrangements in the NER relating to frequency control are appropriate to deal with the current technological transformation underway in the NEM. In particular, The Panel recognises that the outcomes of the *Frequency control frameworks review,* in relation to primary frequency control and FCAS markets, may have direct and indirect impacts on the subsequent assessment of the frequency bands in the FOS. The scope of the *Frequency control frameworks review* is discussed further in section 2.1.3.

The following table outlines the key milestones and dates leading to the delivery of the Panel's final report to the AEMC.

**Table 1.1 Timetable for the Review**

| Milestone | Proposed Date |
|---|---|
| Publication of issues paper | 11 July 2017 |
| Publication of draft determination and Standard – Stage one | 12 September 2017 |
| Publication of final determination and Standard - Stage one | 7 November 2017 |
| Publication of final determination and Standard – Stage two | Q2 2018 |

## 1.4 AEMO Advice

As per NER clause 8.8.1(a)(2) the Panel is required to, "review and, on the advice of AEMO, determine the power system security standards". Therefore, in addition to consulting with key stakeholders, the Panel also obtained advice from AEMO to support its determination of this FOS for stage one of the review.

The content of this advice is described in further detail in section 3.3.

## 1.5 Structure of the determination

The remainder of this determination is structured as follows:

- Chapter 2 describes the background to this review, including a summary of recent and ongoing related work programs.
- Chapter 3 sets out the Panel's assessment approach for this review.
- Chapter 4 sets out the key elements of the FOS determined for stage one of the review.

# 2 Background

The chapter sets the context for this review including a summary of recently completed and ongoing work programs related to this review of the FOS.

The issues paper for this review provides a description of the concept of power system frequency and frequency control in the NEM.[5]

As described in section 1.2, the Panel is undertaking this review of the FOS in response to a terms of reference provided by the AEMC to amend the FOS following the publication of *Emergency frequency control schemes* rule change.[6] At the same time this review takes place during a time of rapid technological and behavioural change in the power system. As the issues paper identified, the performance of the power system frequency in terms of being maintained within a tight band around 50Hz has degraded in recent years.[7]

## 2.1 Related Work Programs and rule changes

There are a number of ongoing work programs that relate to this review, including:

- AEMO, *Future power system security work program*
- AEMC, *Rate of change of power system frequency* rule change
- AEMC, *Inertia ancillary service market* rule change
- AEMC, *Frequency control frameworks review* – commenced July 2017
- AEMC, *Reliability frameworks review* – commenced July 2017

In addition, the Panel will consider work progressed by the Ancillary Services Technical Advisory Group as facilitated by AEMO.

### 2.1.1 Future power system security work program

AEMO is currently developing its Future power system security work program to address operational challenges arising from the changing generation mix in the NEM. Progress reports for this work program were published on 12 August 2016 and 31 January 2017.

In February 2017, as part of this work program, AEMO convened the Ancillary Services Technical Advisory Group, to bring together technical experts from the power industry to investigate solutions for current and future issues relating to ancillary services and power system security. AEMO has engaged the power system advisory firm DIgSILENT to investigate and report on the cause(s) and consequences of the observed changes to the NEM frequency distribution profile.

The final report for the DIgSILENT analysis was published by AEMO on 23 October 2017. The DIgSILENT analysis has confirmed that a reduction in primary frequency response within the NEM during normal operation is a root cause in the degradation of

5 Reliability Panel, *Review of the frequency operating standard* – issues paper, 11 July 2017.

6 AEMC, *Emergency frequency control schemes*, Rule Determination, 30 March 2017.

7 Reliability Panel, *Review of the frequency operating standard* – issues paper, 11 July 2017, pp.23-25.

frequency performance observed in over the last few years. A summary of the key findings and conclusions from the DIgSILENT report is included in box 2.1.

**Box 2.1 Key Findings and conclusions from the DIgSILENT report - Review of Frequency Control Performance in the NEM under Normal Operating Conditions[8]**

**Changes in the power system**

A number of changes in the power system have occurred and are on-going which tend to make the regulation of frequency within the normal operating frequency band (NOFB) more challenging, including:

- Reduction in inertia, with changes in the generation mix. The results show some correlation between frequency excursion size and inertia. Frequency deviations tend to increase with decreasing power system inertia.[9]
- Larger sources of variability within the power system including from large amounts of grid-scale wind and solar generation and solar rooftop PV.
- Reduction in the load-frequency response, due to the increase in inverter-based loads and changing load mix. This reduces the reduction in load as the frequency declines, and vice versa.

**Drivers affecting frequency control**

"The following drivers for reduction in governor frequency response within the NOFB have been identified:

- Governor response within the NOFB is no longer required under the National Electricity Rules
- Governor response represents a cost in terms of wear and tear and efficiency and it is a service that is not paid for.
- As governor response has been withdrawn the remaining stations providing governor response are experiencing greater impact on plant operation, especially frequency oscillations and larger excursions, both of which are assessed by plant owners as representing a risk to the operation of the generating units.
- As frequency control in the NOFB has deteriorated, the cost of regulation service has increased. Some Participants advised they have also reduced governor response to more easily adhere to their AGC targets, in an effort to reduce their Causer Pays contributions.

8 DIgSILENT, *Review of Frequency Control Performance in the NEM under Normal Operating Conditions* – final report prepared for AEMO, 19 September 2017.

9 This issue was considered by the AEMC in the *Managing the rate of change of power system frequency* rule change and *Inertia ancillary service market* rule change.
See:
http://www.aemc.gov.au/Rule-Changes/Managing-the-rate-of-change-of-power-system-freque
http://www.aemc.gov.au/Rule-Changes/Inertia-Ancillary-Service-Market

- In addition, the AER has set compliance with dispatch targets as a priority area for compliance enforcement. Some Participants believe they are better able to achieve dispatch compliance if they do not have their governors responding to frequency variations."

**Opportunities for improvement**

DIgSILENT identified the following actions that may contribute to an improvement in frequency control in the NEM during normal operation:

- The removal of any disincentives to the provision of governor primary frequency response.

  This may, in part, be addressed by AEMO through revision of the causer pays contribution factor procedure which determines contribution factors for the allocation of regulating FCAS costs.

- The removal of the limit on accumulated time error and therefore the requirement to undertake time error correction which contributes to a proportion of automatic generation control (AGC) signals being counter to the actual frequency deviation.[10]

  This limit on accumulated time error is being considered further by the Reliability Panel through the review of the FOS and is discussed in section 4.6.3 of this determination.

- The introduction of a requirement for all generators to provide primary frequency response within the normal operating frequency band or rewarding market participants for providing such a response through a new market or incentive payment.

  This is being considered by the AEMC through the *Frequency control frameworks review,* which is discussed in section 2.1.3 of this determination.

  The Panel recognises that changes to the market and regulatory frameworks in relation to primary frequency control services are likely to have direct and indirect impacts on the FOS. Such interactions will be considered by the Panel during stage two of the review of the FOS, which will commence when the *Frequency control frameworks review* is further progressed.

10 The AGC is a secondary control system that centrally measures the power system frequency and sends out "raise" or "lower" signals to the registered generators and loads that are dispatched to provide regulating FCAS to correct the slow changes in frequency.
Contrary frequency control has been found to occur due to a number of situations where the AGC instruction to generators may run contrary to the recovery of a frequency deviation. For example the frequency is above 50Hz and the AGC system is sending out "raise" signals to generators enabled to provide regulating FCAS. One of the causes of this phenomenon is time error correction.

### 2.1.2 Rate of change of power system frequency and Inertia ancillary service market rule changes

On19 September 2017 the AEMC published a final rule, *Managing the rate of change of power system frequency*. The main features of the rule are:[11]

- An obligation on AEMO to determine sub-networks in the NEM that are required to be able to operate independently as an island and, for each sub-network to:
  - determine the minimum required levels of inertia; and
  - assess whether a shortfall in inertia exists or is likely to exist in the future.
- Where an inertia shortfall exists in a sub-network, an obligation on the relevant TNSPs to make continuously available, minimum required levels of inertia, determined by AEMO. The TNSP can provide the inertia itself or procure inertia services from third parties such as generators.
- An ability for TNSPs to contract with third-party providers of alternative frequency control services ("inertia support activities"), including fast frequency response (FFR) services, as a means of reducing the minimum required levels of inertia, with approval from AEMO.
- An ability for AEMO to enable the inertia network services provided by TNSPs and third-party providers (ie, instruct them to provide inertia) under specific circumstances in order to maintain the power system in a secure operating state.

The introduction of a mechanism to provide inertia additional to the minimum secure operating level may complement the obligation on TNSPs to provide a level of inertia associated with maintaining system security. This would allow for greater power transfer capability across the network, resulting in realisation of market benefits. The AEMC is considering such a market mechanism through the *Inertia ancillary service market* rule change. On 7 November 2017, the AEMC published a draft determination for this rule change. The draft determination sets out the Commission's decision not to make a draft rule relating to the introduction of a market mechanism for additional inertia for market benefit at this time. The Commission intends to continue its assessment of the appropriate design of an inertia market mechanism through the *Frequency control frameworks review*. The Panel will monitor developments with regard to this rule change.[12]

### 2.1.3 Frequency control frameworks review

On the 7 November, the AEMC published an issues paper for the self-initiated the *Frequency control frameworks review*. Through this review the Commission will

11 AEMC, *Managing the rate of change of power system frequency* –rule determination, 19 September 2017, p.iii.

12 AEMC, *System security market frameworks review*- final report, 27 June 2017, pp.36-38.

investigate the appropriateness of the regulatory and market frameworks that relate to frequency control in the NEM. The scope of this review includes:[13]

- assessing whether mandatory governor response requirements should be introduced and investigating any consequential impacts including on the methodology for determining causer pays factors for the recovery of FCAS costs
- reviewing the structure of FCAS markets, to consider:
  - any drivers for changes to the current arrangements, how to most appropriately incorporate FFR services, or alternatively enhancing incentives for FFR services, within the current six second contingency service
  - any longer-term options to facilitate co-optimisation between energy, FCAS and inertia provision
- assessing whether existing frequency control arrangements will remain fit for purpose in light of likely increased ramping requirements, driven by increases in solar PV reducing operational demand at times and therefore leading to increased demand variation within a day
- considering the potential of distributed energy resources to provide frequency control services and any other specific challenges and opportunities associated with, their participation in system security frameworks.

### 2.1.4 Reliability frameworks review

On the 22 August the AEMC published an issues paper for the *Reliability frameworks review*.

This review will consider what changes to existing regulatory and market frameworks are necessary to provide an adequate amount of dispatchable capacity in the NEM to meet the reliability standard. This involves longer-term considerations such as having the right amount of investment, as well as shorter-term operational considerations to make sure an adequate supply is available at a particular point in time. To deliver a reliable supply to consumers it is necessary to always have the level of supply to be greater than current demand to allow for unexpected changes. This margin of supply over demand is termed 'reserves', and essentially acts to deal with unexpected developments.

The Reliability frameworks review will examine the regulatory and market frameworks associated with reliability in a holistic manner, and in the context of the NEM's existing industry structure and drivers of reliability frameworks. It will identify any changes to the current reliability frameworks needed to facilitate the efficient investment, retirement, operation and maintenance decisions that are required to produce an adequate supply of dispatchable capacity, given the current and expected environmental policy mechanisms.

The Reliability frameworks review will address the appropriateness of the existing contingency event framework in the NER in light of the issues raised by AEMO in

13 AEMC, *Frequency control frameworks review* – terms of reference, 7 July 2017.

relation to the current and future power system environment, where variances from demand and intermittent supply may be greater than the loss of a largest generator.[14] The Panel notes the commonality between this issue and the Panel's consideration of the definition of generation event in the FOS, which is discussed in section 4.4.

14 AEMC, 22 August 2017, *Reliability frameworks review* – issues paper, pp.55-59

# 3 Assessment Approach

This chapter sets out the assessment framework that the Panel has considered when undertaking the review of the FOS.

## 3.1 The objective of the review

In undertaking the Review of the FOS, the Panel will be guided by the National electricity objective (NEO) which is set out under section 7 of the National Electricity Law (NEL). The NEO is to

> "The objective of this law is to promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers of electricity with respect to:
>
> - price, quality, safety, reliability and security of supply of electricity; and
> - the reliability, safety and security of the national electricity system."

The Panel considers that the relevant aspects of the NEO for its review of the FOS are the operation of electricity services, with particular respect to the safety and security of the national electricity system and the price, quality and security of supply of electricity.

In undertaking its review, the Panel will exercise its judgement when considering potential changes to components of the FOS, with a view to striking an appropriate balance between providing improved quality and security outcomes against the cost of delivering those outcomes.[15]

The complexity of optimising the FOS is also related to the fact that while changing any specific component of the FOS may change system security outcomes, it is also likely to impose costs on various participants through meeting more strenuous obligations in relation to the elements of the performance standards related to frequency, or on AEMO through a requirement to procure additional ancillary services or constrain dispatch. The setting of each component of the FOS therefore needs to be considered in terms of the balance between these security benefits and costs.

In its assessment of any changes to the components of the FOS and consistent with satisfying the relevant aspects of the NEO outlined above, the Panel will therefore give consideration to the following principles:

- **Supporting a safe and secure system:** the power system can be considered to be secure when it is operated within specified technical operating limits, including voltage and other stability limits. Maintaining the NEM power system within these technical limits allows it to operate effectively, efficiently and safely.

15 In this sense the term "quality" refers to electrical power quality which is a measure of the uniformity of the voltage waveform which describes the fluctuating system voltage and the associated frequency. A high level of power quality relates to a stable system voltage at a steady frequency where the power system is resilient to contingency events. A low level of power quality occurs when the system voltage and frequency fluctuate more widely in response to destabilising events.

Supporting a safe and secure system will be a key consideration of the Panel when determining the FOS.

- **Minimising consequences for the prices consumers pay for electricity:** To maintain the safety and security of the national electricity system, AEMO procures ancillary services and operates the system to keep it within specific limits, generators operate and maintain their units in accordance with performance standards, and network service providers maintain and operate their networks in accordance with system standards.

  These activities come at a cost in terms of obligations faced by participants and AEMO and are ultimately borne by consumers through the price they pay for electricity. The Panel will consider how the settings of the FOS are likely to impact on the costs incurred by different participants in maintaining the security of the system.

Ultimately, the Panel's responsibility in determining the FOS is to identify a reasonable, effective and efficient trade-off between the security benefits of a more stringent FOS, against the costs that this would impose on consumers. While it is essential that minimum limits of security and safety are maintained, this should occur at the lowest possible cost for consumers. Furthermore, the Panel will exercise its judgement in deciding whether additional security benefits above this basic, minimum level are warranted, given the incremental costs of providing that additional security. These trade-offs will be central to all of the Panel's consideration in both stage one and two of the review.

## 3.2 Staging of the review

The Panel is undertaking this review of the FOS in a staged manner, to accommodate changes to the market and regulatory arrangements arising from the work described in section 2.1.

The first stage will address primarily standalone technical and administrative issues and market framework changes stemming from the emergency frequency control scheme rule change.

The second stage will include a general consideration of the various components of the FOS, including the settings of the frequency bands and time requirements for maintenance and restoration of system frequency. Stage two will commence at a later date when the *Frequency control frameworks review* has been further progressed. In particular the Panel recognises the dependence on any changes that the Commission may recommend in relation to the provision of primary frequency control services during normal operation as well as potential changes to the arrangements that relate to FCAS markets. These interdependencies are discussed further in section 3.2.2.

The Panel received 12 submissions from stakeholders in response to the issues paper for this review. These submissions were overwhelmingly in favour of the Panel's staged approach to the review of the FOS.[16] AEMO's submission notes that the two stage

16 Submissions to the *Review of the frequency operating standard* – issues paper: Department of Premier and Cabinet SA, p.1.; ERM Power, p.5; Hydro Tasmania, p.1; Meridian Energy, p.2; Origin Energy, p.1; PIAC, p.1.

approach to the review "allows immediate concerns to be addressed while allowing more complicated, longer-term matters to be informed by analysis underway by AEMO, the AEMC and industry."[17]

Furthermore the submissions to the draft determination from Origin Energy, Meridian Energy and Energy Australia expressed recognition for the fundamental linkages between the review of the FOS and the *Frequency control frameworks review*.[18]

Origin stated in their submission:

> "Origin believes that the outcomes of the Frequency Control Frameworks Review will have the largest impact on setting the frequency bands which will likely affect the level and availability of frequency control services offered to the market. It is imperative that the Panel take into account the effect of these changes before setting the frequency operating bands as any changes by this review will affect how generators operate within the NEM. Mandating governor settings, droop control and the interaction between good frequency control, causer pays factors and meeting 5 minute AGC targets should all be considered by the Panel's when determining the optimum settings for the frequency bands."[19]

While Energy Australia stated:

> "Any assessment of the FOS will need to be informed by the FCFR (Frequency Control Frameworks Review) to ensure that the FOS and the mechanisms proposed to meet it are consistent with each other."[20]

**Discussion of Interdependencies with the *Frequency control frameworks review***

The Panel recognises the strong interdependencies between this review and the outcomes of the AEMC's *Frequency control frameworks review*.[21] The *Frequency control frameworks review* is considering the broader issues relating to frequency control in the NEM including whether any changes should be made to the market and regulatory arrangements to improve frequency control in the NEM.

The elements of the *Frequency control frameworks review* that directly relate to stage two of the review of the FOS include the Commission's consideration of:

- Whether a requirement for primary frequency response during normal operation should be introduced or whether there are alternative means of providing sufficient primary frequency control services to support better frequency control during normal operation.

  Any requirement or incentive for the provision of primary frequency control services is likely to impact the amount (and cost) of regulating FCAS needed to

17 AEMO, Submission to the *Review of the frequency operating standard* – issues paper, p.3.

18 Submissions to the draft determination: Energy Australia, p.3.; Meridian Energy, p.1; Origin Energy, p.2.

19 Origin Energy, Submission to the draft determination, p.2.

20 Energy Australia, Submission to the draft determination, p.3.

21 AEMC, *Frequency control frameworks review* – Issues Paper, 7 November 2017.

keep the frequency within the NOFB boundaries.[22] This may in turn support a change to the value of the NOFB boundaries, as it will affect the total cost of meeting a given set of boundary values.

- Whether existing frequency control arrangements remain fit for purpose and whether the FCAS markets are appropriately structured. Any potential changes to the arrangements for FCAS markets may impact on the Panel's assessment of the trade-off between frequency performance and the cost of contingency FCAS exists when considering the frequency bands in the FOS.

These potential interactions between elements of the FOS and the *Frequency control frameworks review* are the main reason the Panel has decided to commence stage two of the review of the FOS when the *Frequency control frameworks review* is further progressed. This will allow the AEMC and AEMO to progress their analysis and development of the market regulatory frameworks, including any introduction of mandatory governor response and/or primary frequency control, to a stage that is sufficient for the Panel to effectively assess the implications of these changes for the FOS.

The following sections outline the scope of stage one and two of the FOS review.

### 3.2.1 Stage one

This determination presents the Panel's findings in relation to a number of issues identified in the issues paper for immediate action.

The issues that are being actioned with this determination for stage one are:

- Inclusion of a standard to apply to protected events.
- Amendments to the requirements for multiple contingency events
- Review of the definition of terms in the FOS, including:
  - the definition of a generation event.
  - the definitions that relate to island operation in the FOS
- Review of the requirement for accumulated time error in the FOS

Chapter four describes the Panel's considerations in relation to addressing these issues in the related changes that are included in the FOS.

### 3.2.2 Stage two

Stage two of the review will commence at a later date when the *Frequency control frameworks review* has been further progressed. Stage two will involve an assessment of each of the elements of the FOS, including the boundaries of the various frequency bands and the timeframes for restoration of power system frequency following a specific event.

This assessment requires consideration of the complex interactions between the regulatory and market frameworks and the various elements of the FOS. This will in

22 Primary frequency control tends to act in tandem with regulation FCAS to dampen smaller frequency variations. Increased volumes of primary frequency control may therefore improve the function and therefore reduce the required quantity of regulating FCAS.

turn require consideration of the trade-offs between system security impacts and costs for consumers.

The draft determination set out the Panel's initial thoughts on approaching this assessment by considering three broad sets of power system conditions:[23]

- normal operation – no contingency events
- management of credible contingency events
- management of emergency conditions.

In addition, stage two of the review will also consider the following issues identified through the course of stage one:

- whether it is appropriate to remove the current limit in the FOS on accumulated time error.
- whether the FOS should include a limit on ROCOF[24]
- improvements to the structure and consistency of the FOS document itself.[25]

**Stakeholder submissions related to scope of stage two**

The Panel received six submissions from stakeholders in response to Panel's initial discussion of issues for stage two of the review, set out in the Stage one draft determination. Four of these submissions included feedback in relation to the issues identified for consideration through stage two of the review.

The submissions from Origin Energy, Meridian Energy and Energy Australia expressed recognition for the fundamental linkages between the review of the FOS and the AEMC Frequency control frameworks review.[26]

The submission from Meridian Energy recommended that, in its determination of the FOS, the Panel review and consider any relevant recommendations from the AER's investigation into the system black event that occurred in South Australia in September 2016.[27] The Panel notes that at the time of publication the AER review of the black system event in South Australia had not yet been published.

The submission from Energy Australia commented on a number of issues related to stage two including:[28]

- Support for the exploration of the removal of the limit on accumulated time error, along with expressing the importance of widespread community engagement on this issue to avoid serious unintended consequences.

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23 Reliability Panel, *Review of the Frequency operating standard* – Stage one draft determination, 12 September 2017.

24 Submission to the issues paper: ENA, p.5; Engie, p.5; TasNetworks, pp.8-9; Department of the Premier and Cabinet - South Australia, pp.7-8.
ENA, Submission to the draft determination, p.2.

25 AEMO, *Review of the frequency operating standard*, stage 1 – request for advice, 18 August 2017, p.11.

26 Submissions to the draft determination: Energy Australia, p.3.; Meridian Energy, p.1; Origin Energy, p.2.

27 Meridian Energy, Submission to the draft determination, p.1.

28 Energy Australia, Submission to the draft determination, p.1

- Support for the reassessment of the 99% requirement to maintain the power system frequency within the NOFB and corresponding 1 % allowance for exceeding the NOFB but staying within the normal operating frequency excursion band.

  Such a consideration should include the identification of a preferred frequency distribution for normal operation along with how such a distribution could be achieved and the costs of achieving it.

- To inform the assessment of the undertake an international comparison of best practise frequency control both in terms of the respective frequency bands and the mechanisms that exist to maintain good frequency control.

Origin Energy also commented on a number of issues related to stage two of the review, including:[29]

- the view that the removal of the limit on accumulated time error through this review of the FOS is premature and the Panel should evaluate the impact of the relaxation of the time error limit for a longer period. A decision to remove the limit on time error should be delayed until the next review of the FOS to allow for this evaluation.
- when setting the boundaries of the frequency bands in the FOS the Panel should consider:
  - the availability of regulation and contingency FCAS and the interaction of this availability with prices in the energy market
  - the impact of the Frequency control frameworks review and any associated reforms that impact generator governor settings
  - the impact of increasing frequency fluctuations in the NEM during normal operation and the increased wear and tear costs borne by generators as a result of this
  - the impact of fast frequency response services
  - a general discussion on the definition of credible contingencies

The submission from the ENA reiterated its interest to further investigate the inclusion of a limit on rate of change of frequency within the FOS and the potential benefits of including a performance measure in relation to accumulated time error.[30]

The Panel appreciates these comments and will take them into account during stage two of the review.

## 3.3 AEMO advice

In determining the FOS, the Panel sought and received relevant technical advice from AEMO relating to the operation of the NEM power system.[31]

29 Origin Energy, Submission to the draft determination, pp.1-2

30 ENA, Submission to the draft determination, p.1.

The AEMO advice for stage one of the FOS review covers the issues identified for consideration in stage one as set out in section 3.2.1.

A summary of the AEMO advice related to each of these issues is included within the "stakeholder views" sections for each of the stage one issues discussed in Chapter 4.

31 AEMO, *Review of the frequency operating standard*, stage 1 – request for advice, 18 August 2017. See: http://www.aemc.gov.au/Markets-Reviews-Advice/Review-of-the-Frequency-Operating-Standard

# 4 The FOS

This chapter outlines the key features of the Panel's determination of the FOS, as a result of the completion of stage one of the review.

- Section 4.1 provides an overview of the key revisions in the FOS. The following sections then describe the Panel's considerations for each of these changes:
- Section 4.2 describes the inclusion of a standard to apply to protected events.
- Section 4.3 describes amendments to the requirements for multiple contingency events.
- Section 4.4 describes the definition of the term, 'generation event'.
- Section 4.5 describes definition of the terms related to island operation.
- Section 4.6 describes the requirement for accumulated time error.
- Section 4.7 sets out the arrangements and timing for the implementation of the new FOS.

## 4.1 Overview of the FOS

The Panel has made the following changes which are incorporated in the FOS for Tasmania and for the mainland:

- inclusion of a standard for protected events
- revision of the requirements in the FOS in relation to multiple contingency events
- expansion of the limit for accumulated time error in the mainland.
- revision of the definition of "generation event"
- revision of the definitions related to island operation.

Box 4.1 presents the key elements of the FOS which is found in full in Appendix A.[32]

**Box 4.1 Key elements of the revised FOS**

**1) Protected events**

The FOS sets out a standard for protected events. This is the same as the interim standard that was applied for protected events following the Emergency frequency control schemes rule change. The FOS states that following a protected event, the frequency should remain within the emergency frequency excursion tolerance limits.

**FOS - Part B (f)**

"as a result of any protected event, system frequency should not exceed

32 The FOS for the mainland NEM is set out it Appendix A.1.
The FOS for Tasmania is set out in Appendix A.2.
The definitions that apply for both the Tasmanian and the mainland FOS have been combined and are set out in Appendix A.3.

the *extreme frequency excursion tolerance limits* and should not exceed 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."

**2) Multiple contingency events**

The FOS includes a revised requirement for multiple contingency events. The revised requirement requires AEMO use "reasonable endeavours" to stabilise and restore the power system following non-credible contingency event and multiple contingency event that are not protected events.

**FOS - Part B (g)**

"following the occurrence of any *non-credible contingency event* or *multiple contingency event* that is not a *protected event*, AEMO should use reasonable 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 exceeding the applicable *normal operating frequency band* for more than ten minutes while there is no contingency event.

**3) Definition of Generation event**

The FOS includes an amended definition of generation event, to include in this definition the rapid and unexpected change in output from one or more generating systems.

The definition of generation event in the FOS:

"means:

1. a *synchronisation* of a *generating unit* of more than 50 MW, or
2. an event that result in the sudden, unexpected and significant increase or decrease in the *generation* of one or more *generating systems,* totalling more than 50MW in aggregate within a period of 30 seconds or less, or
3. a *credible contingency event*, not arising from a load event, a *network event*, a *separation event* or a part of a *multiple contingency event*."

**4) Definition of an "island" for the FOS**

The FOS includes an amended definition of the term "island" to specify that an island must be no smaller than an inertia sub-network.

The definition of the term "island" in the FOS is :

"means a part of the *power system* that includes *generation*, *networks* and *load*, for which all of its alternating current 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 combined *generation* of the *regions* formed by the separation event(determined by available capacity before disconnection); and
(b) contains at least one whole *inertia sub-network*."

The definition of inertia sub network is added to the FOS as:
"has the meaning given to it in the rules."

**5) Accumulated time error:**

The limit on accumulated time error for the mainland in the FOS has been increased from 5 to 15 seconds.

The limit on accumulated time error for Tasmania in the FOS remains unchanged at 15 seconds.

## 4.2 Inclusion of protected events in the FOS

As discussed in the issues paper, the *Emergency frequency control schemes* final rule introduced into the NER a new classification of contingency event, the protected event.[33] A protected event is a non-credible contingency event that is defined by AEMO and declared by the Panel. It may include any non-credible event or multiple contingency event, where the cost of managing the event as a protected event is in the long term interest of consumers, in accordance with the NEO.[34]

The Panel has determined the FOS that should apply following the occurrence of a protected event. Accordingly, Part B(f) of the FOS includes a requirement that:

> "as a result of any protected event, system frequency should not exceed the *extreme frequency excursion tolerance limits* and should not exceed 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."

This FOS for protected events is the same as the interim FOS that was included in the NER as part of the *Emergency frequency control schemes* rule, which introduced the concept of protected events to the NER.[35]

### 4.2.1 Current requirements of the interim FOS

While the FOS for Tasmania and for the mainland do not currently include a standard for protected events, chapter 11 of the NER includes an interim FOS that applies to all protected events, until such time as the Panel determines the frequency standard that applies for a protected event.[36] This interim FOS was included in the NER as part of the *Emergency frequency control schemes* rule.

33 Reliability Panel, Review of the frequency operating standard – Issues paper, 11, July 2017, p.39.

34 AEMC, 2017, *Emergency frequency control schemes*, rule determination, 30 March 2017, pp.62-65.

35 AEMC, 2017, *Emergency frequency control schemes*, rule determination, 30 March 2017.

36 NER cl. 11.97.2 Interim frequency operating standards for protected events.

The interim FOS for a protected event is currently set out for Tasmania and for the mainland as follows:

> "For a protected event, system frequency should not exceed the applicable extreme frequency excursion tolerance limits and should not exceed the applicable load change band 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."

### 4.2.2 Stakeholder views

**Submissions to the stage one draft determination**

Most of the submissions received to the draft determination expressed support for the proposed FOS for protected events.[37] The submission from Energy Australia also expressed support for the proposed FOS for protected events, however Energy Australia also suggested that the lower bounds of the frequency band that applies for protected events should be considered further in stage two of the review of the FOS.[38] Energy Australia noted that:

> "The ability for some generating units to continue to operate under 48Hz has been raised in a previous review of the FOS, with some generating units having performance standards that allow them to trip below that frequency. Given the purpose of these limits is to set parameters under which a cascade failure can be avoided, it needs to be clarified whether allowing the frequency to drop below 48Hz achieves this and whether the use of emergency frequency control schemes (EFCS) should be aimed at ensuring the frequency does not deviate below 48Hz."

The Panel's response to this submission is included below in section 4.2.3.

**Submissions to the issues paper**

Most of the submissions received to the issues paper indicated support for the continuation of the interim FOS for protected events.[39] Within the context of assessing the costs and benefits of applying a tighter or a narrower frequency band for protected events, Energy Australia noted in their submission that:

> "We consider that the ultimate goal of the Reliability Panel should be to keep the parameters as close to the appropriate non-credible contingency definition as possible."[40]

Origin Energy noted in their submission that the frequency band in the FOS for a protected event should be set such that:

> "AEMO use a combination of market mechanisms and EFCS to maintain the NEM in a satisfactory operating state."[41]

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37 Submissions to the draft determination: ENA, p.1.; Meridian, p.1.; AEMO, pp.1,2.

38 Energy Australia, Submission to the draft determination, pp.1-2.

39 Submissions to the issues paper: ENA, p.2; AEMO, p.5; TasNetworks, p.6.

40 Energy Australia, Submission to the issues paper, p.3.

The Panel understands that in order for a combination of market mechanisms and EFCS to be utilised to manage protected events, the applicable frequency band is required to be wider than the operation frequency tolerance band, to allow for the operation of EFCS based on frequency relays.[42]

A number of stakeholders noted that the FOS for protected events should be set so as to minimise the cost to consumers.[43]

Some stakeholders suggested that it would be appropriate for individual frequency standards to be defined for each protected event, and that these should be determined through bespoke cost benefit analysis.[44] However, Energy Australia recognised in their submission that the benefits of a consistent approach may be more cost effective than the complexity of setting targeted standards for a large number of protected events.[45]

ERM argued that due the potential for significant impacts from a protected event, the FOS for a protected event should be set tighter than the current FOS for multiple contingencies, at a similar level to that of a separation event.[46]

The South Australian government submission indicated support for the continuation of the interim FOS for protected events, as a starting point, noting that in the event of a protected event, the operation of under frequency EFCS ,"may or may not be successful to avoid cascaded failure depending on the ROCOF at the time". The SA government argues that to address this issue, the Panel should consider including a rate of change of frequency (ROCOF) limit in the FOS for protected events and in the FOS more generally.[47] The consideration of whether the FOS should contain a ROCOF limit is mentioned in section 5.4 as an issue for consideration in stage two of this review.

**AEMO Advice**

AEMO's advice to the Panel for this review supported the continued application of the interim protected events standard for inclusion in the FOS for the mainland and for Tasmania. AEMO's advice noted that maintaining the power system within the broadest frequency band, the extreme frequency excursion tolerance limit, is appropriate as it allows "flexibility in operational response and economic efficiency to be realised". AEMO stated that:[48]

> "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

41 Origin Energy, Submission to the issues paper, p.1.

42 Such as the under frequency load shedding schemes that operate below 49Hz.

43 Submissions to the issues paper: PIAC, p.1; Energy Australia p.3.

44 Submissions to the issues paper: Engie, pp.3-4; Meridian, p.2.

45 Energy Australia, Submission to the issues paper, p.3-4.

46 ERM Power, submission to the issues paper, p.2.

47 Department of the Premier and Cabinet - South Australia, Submission to the issues paper, p.5.

48 AEMO, *Review of the frequency operating standard*, stage 1 – request for advice, 18 August 2017, p.2.

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."

### 4.2.3 Panel's consideration of the FOS for protected events

The FOS for Tasmania and for the mainland each has been revised to include a frequency band and restoration times to apply following the occurrence of a protected event. The frequency band that applies following a protected event is the extreme frequency excursion tolerance limit, which is the widest possible frequency band that can apply under the current FOS.[49] The FOS includes a standard for protected events which is unchanged from the interim FOS for protected events.

The Panel considers that this element of the FOS is consistent with the functional purpose of a protected event, which is to limit or reduce the consequences of the non-credible contingency where it is economic to do so.[50]

Setting the allowable frequency following a protected event at the extreme frequency excursion tolerance limit allows AEMO a degree of flexibility in terms of how it manages the frequency consequences of the event, while also helping to limit the extent of the potential costs of the market measures that would be required to maintain the power system frequency in accordance with the FOS.

As stated in AEMO's advice to the Panel, the Panel's approach in the FOS is consistent with the purpose defined in the *Emergency frequency control scheme* rule change, as it maximises the operational flexibility for AEMO in managing the protected event while limiting the ongoing market costs that would be borne by unnecessarily constraining the market to limit the impacts of high impact, low probability events.

This functional purpose of the protected event was established by the AEMC in its final determination for the *Emergency frequency control schemes* rule change. The purpose of a protected event is to limit the consequence of certain high consequence non-credible contingency events, the occurrence of which may otherwise lead to cascading outages that may result in major supply disruptions and potentially a black system condition for all or part of the power system.[51] AEMO identifies such events through the power system frequency risk review; the goal of which is defined in NER clause 5.20A.1(a)(1) as to review the management of:

> "*non-credible contingency events* the occurrence of which AEMO expects would be likely to involve uncontrolled increases or decreases in *frequency* (alone or in combination) leading to *cascading outages*, or *major supply disruptions*;"[52]

Where a protected event is declared, AEMO is able to use a combination of emergency frequency control schemes (generation or load shedding) and the application of

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49 The extreme frequency excursion tolerance limit is based on the technical limits of power system equipment.

50 The Reliability Panel considers the costs and benefits of declaring a protected event in accordance with NER cl.8.8.4(d)

51 AEMC, 2017, *Emergency frequency control schemes*, rule determination, 30 March 2017, pp.43-44.

52 NER cl. 5.20A.1(a)(1)

operational constraints in order to maintain the power system frequency in accordance with the FOS.

Given that the ultimate purpose of the protected event is to prevent the system collapsing into a black system condition, the Panel considers that the extreme frequency excursion tolerance limit forms the appropriate frequency band for a protected event. This is because AEMO prevents a cascading outage and potential black system by preventing the frequency from moving outside of these extreme limits.[53]

In relation to the South Australian government's request that the Panel includes a ROCOF standard as an element of the standard for protected events, the Panel considers that such an inclusion is not warranted at this time. The Panel is of the view that AEMO's system security responsibility for returning the power system to a satisfactory operating state following a protected event is clearly set out in the NER.[54] Furthermore AEMO is required to operate the power system within the limits of the technical envelope.[55] This would include consideration of the capability of operating generation plant, network elements and EFCS, including how this plant is likely to perform under potential ROCOF scenarios that may result for the occurrence of the protected event.

The concept for the inclusion in the FOS of a general limit on rate of change of frequency was raised in submissions by ENA, Engie and TasNetworks.[56] This issue is mentioned in section 5.4 as an issue for further consideration during stage two of the review and is also being considered in the AEMC's *Managing the rate of change of frequency* rule change, which is scheduled to publish a final determination on 19 September 2017.[57]

**Alternative approaches**

In setting the standard for protected events the Panel considered a number of alternative approaches including:

- Setting a protected event frequency band that was narrower than the extreme frequency excursion tolerance limit but wider than the operational frequency tolerance band.[58]
- Allowing the FOS for each protected event to be determined on a case by case basis.

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53 The extreme frequency excursion tolerance limits represent the limit of the physical operational capabilities of most generating units in the NEM. If the frequency moves outside of this limit, it is likely that protection systems will cause generators to trip, in order to protect the generating equipment, further worsening the frequency deviation and causing subsequent generators to trip in a cascading outage, potentially leading to a total collapse of system voltage. Thus, by preventing the frequency moving outside of these limits, the risk of a cascading outage and black system is significantly reduced.

54 NER clause 4.2.4

55 NER clause 4.3.1(e)

56 Submissions to the issues paper: ENA, p.5; Engie, p.5. TasNetworks, pp.8-9.

57 See: http://www.aemc.gov.au/Rule-Changes/Managing-the-rate-of-change-of-power-system-freque

58 In order to allow the operation of relay based emergency frequency control schemes the FOS for protected events must be wider that the operational frequency tolerance band.

*Setting a standard for protected events that is narrower than the extreme frequency excursion tolerance limit*

As suggested by the ERM Power submission to the issues paper, the Panel considered whether there is a basis for setting the protected event FOS at some frequency band that is narrower than the extreme frequency excursion tolerance limit. This would result in a degree of an additional security "buffer" for protected events that are declared, as AEMO would be required to operate the system more conservatively than if a wider protected event FOS were defined.

The submission by Energy Australia to the draft determination noted that a narrower frequency band may better accommodate older generators with grandfathered technical performance standards in relation to frequency disturbances. These grandfathered generator technical performance standard for older generators in Victoria and New South Wales were considered by the Panel in 2009 for the determination of the FOS that applies in the mainland during supply scarcity.[59]

The frequency bands that apply for a generation, load or network event in the mainland during supply scarcity are:[60]

- 48 to 52 Hz (Queensland and South Australia)
- 48.5 to 52 Hz (New South Wales and Victoria)

The rationale for these settings was set out in the Panel's determination of the FOS in 2009:[61]

> "The Panel considers that the risk of further generating units tripping on under frequency is low as the minimum access standards require generating units to be able to operate down to 47 Hz on the mainland. However, […], some generating units may have grandfathered performance standards that mean they may be at an increased risk of tripping at minimum frequencies of 47.5 Hz as originally proposed and 48 Hz in the case of some generating units in Victoria and New South Wales."

The Panel recognise that it is appropriate to consider the application of this narrower band for protected events, to account for such grandfathered generator technical performance standards. However setting such a band may increase FCAS costs and potentially result in the application of additional interconnector constraints, which the Panel would need to consider when assessing a request for the determination of a protected event.

The Panel considers that the goal of the generation, load and network contingency bands that apply during supply scarcity is different to that of managing protected events. For the former, the operational goal is the restoration of load, following a load

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59 Energy Australia, Submission to the draft determination, pp.1-2.

60 A state of supply scarcity means the condition where load has been disconnected either manually or automatically, other than in accordance with dispatch instructions or service provision, and not yet restored to supply.

61 Reliability Panel, *Application of frequency operating standards during periods of supply scarcity* – Final Report, 15 April 2009, p.14.

shedding event whereas for the latter the operational goal is to avoid a cascading outage that may result following a non-credible event, a protected event.

The Panel therefore considers that it is appropriate for the wider extreme frequency tolerance limit to apply for protected events. In planning for a protected event and managing the power system following such an event, AEMO would need to operate the system based on the technical performance limits of the operational power system equipment. This would include accounting for the actual performance capabilities of any generators with grandfathered frequency performance standards.

The Panel consider that application of such a narrower band for protected events would be expected to decrease the operational flexibility for managing protected events and increase the cost of operational measures, including FCAS costs and the market costs resulting from the application of interconnector constraints. Any additional costs would need to be considered by the Panel when assessing a request for the determination of a protected event, effectively raising the bar for a protected event to be shown to be in the economic interest of customers in the NEM.

For this reason the standard for protected events in the FOS is set equal to the extreme frequency excursion tolerance limits, to maximise operational flexibility as much as is practical and limit the operational costs of preventing a cascading outage subsequent to one of these events occurring.

*Determining the FOS for protected events on a case by case basis*

As noted by a number of stakeholder submissions, another option for setting a FOS for protected events is that the applicable standard be set on a case by case basis, based on a cost benefit trade-off for each protected event.[62]

This is an approach that was discussed in the AEMC *Emergency frequency control schemes* final determination, which noted that, "there is limited scope for a hi-fidelity approach to setting various post contingency operating states for each protected event."[63] The Commission's final rule included "a single post contingent operating state for protected events in the frequency operating standards (to be determined by the Reliability Panel)."[64]

The Panel recognises that setting a bespoke FOS for each protected event is not likely to be practical and that the regulatory complexity of such an approach would outweigh any benefit from the setting of customised standards for protected events.

As required by clause 8.8.4(d) of the NER, the Panel will consider the costs and benefits of particular protected events when assessing an application from AEMO for the determination of a protected event and any associated protected event EFCS standard.

## 4.3 Amendments to the requirements for multiple contingency events

The FOS has been revised to require AEMO to use "reasonable endeavours" to stabilise and restore the power system following non-credible contingency events and multiple

62 Submissions to the issues paper: Engie, pp.3-4; Meridian, p.2, Energy Australia, pp.3-4.

63 AEMC, 2017, *Emergency frequency control schemes*, rule determination, 30 March 2017, pp.36-37.

64 Ibid.

contingency events that are not protected events. This change is actually a relaxation of the existing obligation for multiple contingency events. Part B(g) in the FOS states:

> "following the occurrence of any *non-credible contingency event* or *multiple contingency event* that is not a *protected event*, AEMO should use reasonable 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 exceeding the applicable *normal operating frequency band* for more than ten minutes while there is no contingency event."

The revision of the multiple contingency requirement to include 'reasonable endeavours' reflects the impracticality of maintaining the power system frequency within a prescribed band following the occurrence of all possible multiple contingency events. This 'reasonable endeavours' obligation sets out the performance objective for management of multiple contingency events; i.e. to the extent that it is reasonably possible for AEMO to do so, AEMO should maintain the power system frequency within the extreme frequency excursion tolerance limits. The Panel considers that this target will help to guide AEMO in its coordination of emergency frequency control schemes and that it will help guide AEMO's efforts to restore power system security following the occurrence of a non-credible contingency event.

### 4.3.1 Current requirements of the FOS

The existing FOS for Tasmania and the mainland each require AEMO to maintain the power system frequency within the extreme frequency excursion tolerance limits following any multiple contingency event.

This obligation is contained in part B (f) of the existing FOS which states that:

> "as a result of any multiple contingency event, system frequency should not exceed the *extreme frequency excursion tolerance limits* and should not exceed 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."

### 4.3.2 Stakeholder views

**Submissions to the stage one draft determination**

Most stakeholder submissions to the draft determination indicated support for the revision of the multiple contingency requirement as set out in the draft FOS.[65]

The submission from Origin Energy recognised that the requirement for multiple contingencies in the draft FOS, "allows a slight relaxation of AEMO's obligation". Furthermore, in response to suggestions that the multiple contingency requirement should be removed from the FOS, Origin stated:

65 Submissions to the draft determination: ENA, p.2; Origin Energy, p.1; Meridian Energy, p.1.

> "Origin does not support this viewpoint, and as above, supports maintaining a clear obligation on AEMO to manage frequency within the FOS for these types of events."[66]

The AEMO submission to the draft determination argues that:

> "The inclusion of the proposed provisions concerning multiple contingency events in the FOS creates material ambiguity in relation to AEMO's obligations, and potentially conflicts with the framework established by the EFCS Rule." [67]

AEMO's submission explains that the only means by which it can pre-emptively prepare the system for the consequences of non-credible contingencies (other than protected events) is through the coordination of an emergency frequency control scheme. Otherwise AEMO's actions are limited to its efforts to restore power system security after the occurrence of the non-credible event.[68]

AEMO's submission also suggests that the revised requirement of multiple contingency events is potentially inconsistent with clause 4.2.6(b) of the NER which states that:

> "Following a contingency event (whether or not a credible contingency event) or a significant change in power system conditions, AEMO should take all reasonable actions:
>
> (1) to adjust, wherever possible, the operating conditions with a view to returning the power system to a secure operating state as soon as it is practical to do so, and, in any event, within thirty minutes;"[69]

AEMO considers that the requirement in the FOS for it to use "reasonable endeavours" to restore the powers system frequency back to the NOFB within 10 minutes may require it to consider interrupting customer load significantly earlier than 30 minutes that would otherwise be required by the NER.[70]

The Panel agrees with AEMO's comments in relation to the actions that may be taken prior to a non-credible contingency event that is not a protected event. These pre-emptive actions are limited to the coordination of emergency frequency control schemes with reference to industry practice.[71] However the Panel consider that this "reasonable endeavours" requirement is consistent with the NER. This requirement aligns to target the time to restore the system frequency to the NOFB within 10 minutes, with the access standards for a generating unit response to frequency disturbances set

66 Origin Energy, Submission to the draft determination, p.1.

67 AEMO, Submission to the draft determination, p.1.

68 Ibid.

69 NER Clause 4.2.6(b)

70 AEMO, Submission to the draft determination, p.3.

71 The specification of the emergency frequency control schemes are reviewed and determined by AEMO through the power system frequency risk review. The process for undertaking the power system frequency risk review is set out in clause 5.20A.1 and 5.20A.2 of the NER.

out in NER S5.2.5.3.[72] The Panel's reasoning for this determination is discussed further in section 4.3.3.

**Submissions to the issues paper**

A majority of stakeholder submissions supported the removal of a firm obligation to maintain the power system frequency within a given frequency band for multiple contingency events.

However several stakeholders also argued for the retention of some form of general requirement for AEMO to make reasonable attempts to restore the satisfactory operation of the power system following such events.[73]

For example, Engie recognised that there is no practical way that AEMO can respond to the standard for multiple contingency events, other than through a 'best endeavours' type approach. [74]

Similarly, Energy Australia supported either the rephrasing of the multiple contingency requirement in the FOS as a general obligation. Alternatively, Energy Australia suggested specifying the types of multiple contingency events for which the FOS should be maintained, with a firm obligation applied to prevent system collapse for these specific events.[75]

Similarly, ERM supported the firming up of the multiple contingency requirement in the FOS, suggesting that: "the Panel give consideration to redefining the condition to that of the simultaneous trip of all units at the biggest power station defined on a per region basis."

The Government of South Australia noted there may be a benefit in clarifying the performance specification for EFCS as a catch all mechanism to mitigate the impact of contingency events that are not protected events or credible contingencies. The Government of South Australia also recognised that the declaration of protected events is likely to protect against the most significant regional non-credible contingencies, and as such there is little reason for any specific regional requirements in relation to multiple contingencies.[76]

**AEMO advice**

AEMO's advice to the Panel in relation to the inclusion of a general obligation for multiple contingency events in the FOS, is that such an obligation is not required, as

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72 Thus following a significant frequency excursion due to a multiple contingency event and recognizing that there will be limited options to act in the short 10 minute window as well as having competing priorities to manage, AEMO will need to evaluate whether the frequency will be consistent with the normal frequency operating band. If it deems that there is an unacceptable risk to system security, AEMO may take additional action which by that stage is most likely to involve tripping of load.

73 Submissions to the issues paper: ENA, p.2; SACOSS, p.1; TasNetworks, p.6.

74 Engie, Submission to the issues paper, p.4.

75 Energy Australia, Submission to the issues paper, pp.3-4.

76 Department of the Premier and Cabinet - South Australia, Submission to the issues paper, p.6.

AEMO considers that responsibility for managing the impacts of multiple contingency events are clearly defined in the NER.[77]

AEMO claims that clause 4.2.6 of the NER places an obligation on AEMO to coordinate the operation of EFCS to "significantly reduce the risk of cascading outages and major supply disruptions following significant multiple contingency events". NSP's in consultation with AEMO also have an obligation to ensure that:[78]

> "sufficient *load* is under the control of under frequency relays or other *facilities* where required to minimise or reduce the risk that in the event of the sudden, unplanned simultaneous occurrence of multiple *contingency events*, the *power system frequency* moves outside the *extreme frequency excursion tolerance limits*;

AEMO state in their submission that:

> "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."

### 4.3.3 Panel's considerations in relation to multiple contingency events

The Panel recognises that there is a need to revise the requirement in the FOS that applies following the occurrence of a multiple contingency event, as the existing requirement is impractical and impossible to fully comply with. Multiple contingency events include an unlimited number of potential events and as such are essentially undefinable. They may include events ranging from the simultaneous loss of two generators (a more probable event), to the simultaneous loss of all generators in a region (an extremely improbable event).

> The NER require that AEMO must use its reasonable endeavours to achieve its power system security responsibilities in accordance with the power system security principles, which include a requirement that: "emergency frequency control schemes are required to 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." [79]

The Panel considers that it is appropriate and practical that this principle in the NER be clarified by maintaining a clear obligation on AEMO to manage the frequency limits set out in the FOS in relation to multiple contingency events. However the Panel recognises that it is not practical to impose a firm performance obligation on AEMO in relation to all possible multiple contingency events. Therefore the requirement in the FOS is for AEMO to use 'reasonable endeavours' to maintain and restore the power system

77 AEMO, *Review of the frequency operating standard*, stage 1 – request for advice, 18 August 2017, pp.3-4.

78 NER clause S5.1.10.1(a)

79 NER Clause 4.2.6(c)

frequency following the occurrence of any non-credible contingency event or multiple contingency event that is not a protected event. This requirement specifies the performance target that AEMO should use reasonable endeavours to meet in accordance with the general system security principles in the NER.[80]

The Panel notes that the *Emergency frequency control schemes* final rule revised the power system security principles, including clause 4.2.6(c) of the NER to change what it is that AEMO needed to consider when managing of multiple contingency events. Prior to the final rule being made, NER clause 4.2.6(c) stated:

> "Adequate *load shedding* facilities initiated automatically by *frequency* conditions outside the *normal operating frequency excursion band* should be available and in service to restore the *power system* to a *satisfactory operating state* following significant *multiple contingency events*."[81]

The Panel recognises that to operate the power system to achieve this principle is impractical and impossible to achieve for all multiple contingency events, as set out in the AEMC *Emergency frequency control schemes* final determination.[82]

However the Panel also recognises the value in clarifying the risks that AEMO should consider when managing multiple contingency events. For example, historically, under frequency load shedding schemes have been designed and coordinated to help maintain the frequency within the extreme frequency tolerance band in the event of sudden and significant non-credible contingency events.

Therefore the Panel considers it appropriate that the FOS reflect the altered power system security principle in the NER by requiring AEMO to take reasonable endeavours to maintain the power system frequency within the extreme frequency excursion tolerance limits following the occurrence of any non-credible contingency event or multiple contingency event that is not a protected event. This obligation clarifies that AEMO will take reasonable actions to maintain the frequency of the power system, following the occurrence of a multiple contingency event that is not a protected event, taking into account the surrounding circumstances. The Panel considers that this general obligation is not likely to be place a significant additional burden on AEMO, as it clarifies the goal for operation of the power system during emergency conditions.[83]

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80 NER Clause 4.2.6

Similarly NER clause 4.2.6(b) states that:

"Following a *contingency event* (whether or not a *credible contingency event*) or a significant change in *power system* conditions, AEMO should take all reasonable action:

(1) to adjust, wherever possible, the operating conditions with a view to returning the *power system* to a *secure operating state* as soon as it is practical to do so, and, in any event, within thirty minutes; or

(2) if any principles and guidelines have been *published* under clause 8.8.1(a)(2a), to adjust, wherever possible, the operating conditions, in accordance with such principles and guidelines, with a view to returning the *power system* to a *secure operating state* within at most thirty minutes.

81 NER version 89, clause 4.2.6(c)

82 AEMC, 30 March 2017, *Emergency frequency control schemes* - final determination, p.46.

83 That is, to make reasonable attempts to maintain the power system frequency within the extreme frequency excursion tolerance limit and then ultimately to attempt to return the power system to the normal operating frequency band.

The Panel considers that this multiple contingency requirement in the FOS will assist AEMO by providing clarity and guidance as to how it should prepare for and manage the impact of non-credible contingencies and multiple contingencies that are not protected events, while avoiding imposing undue restrictions on its operational discretion. The Panel considers that retaining some reference to multiple contingencies in the FOS will:

- provide a performance target for the development of AEMO's operational procedures following a significant contingency event
- provide a performance target for the design of general purpose emergency frequency control schemes, such as under frequency load shedding schemes, which provide the last line of defence to protect the power system from emergency events
- maintain the alignment between the FOS and the NER in respect of a generating unit response to frequency control (i.e., the ability for a generating unit to operate continuously within prescribed frequency bands for defined time periods)
- maintain AEMO's the discretion and flexibility as to how power system frequency risks are managed.[84]

This element of the FOS is consistent with the AEMC's approach to the management of power system frequency risks as set out in the final determination for the *Emergency frequency control schemes* rule; the final rule includes:[85]

> "Recognition that general purpose emergency frequency control schemes and special emergency frequency control schemes are functionally different and treating them so through different processes:
>
> — Special emergency frequency control schemes are linked to the mitigation of one or more protected events and credible contingency events
>
> — General purpose emergency frequency control schemes are linked to the mitigation of non-credible contingency events."

Maintaining the multiple contingency requirement in the FOS provides a general performance target for general purpose emergency frequency control schemes that are not intended to be linked to specific protected events. These general purpose schemes provide general protection against non-credible contingencies and multiple contingency events.

The Panel recognise the importance of maintaining the alignment between the system security standards and the performance standards for generators connected to the NEM. The multiple contingency requirement in Part B (g) of the FOS reflects the access standards for a generating unit response to frequency disturbances set out in NER

84 AEMO is required to undertake a power system frequency risk review every two years in accordance with rule 5.20A of the NER. This review includes an assessment of the risks of non-credible contingency events that may lead to cascading outages and the options for management of those events, including the development of new or modified emergency frequency control schemes and the request for the declaration of protected events.

85 AEMC, 2017, *Emergency frequency control schemes*, rule determination, 30 March 2017, p.36.

S5.2.5.3. The automatic access standard includes the requirement that a generating unit shall be able to operate continuously outside the operational frequency tolerance band but within the extreme frequency tolerance excursion for at least the stabilisation time of two minutes. Furthermore to meet the automatic access standard, set out in NER S5.2.5.3, a generating unit shall be able to operate outside the NOFB and within the operational frequency tolerance band for at least the recovery time of ten minutes.[86] The revised Part B (g) maintains the reference to the extreme frequency tolerance excursion limit along with the stabilisation and restoration times, in line with this automatic access standard for the connection of generators.

The Panel considers that the alignment of Part B (g) of the FOS and the access standards for generating unit response to frequency disturbances is important as this aligns AEMO efforts to restore the power system following non-credible contingency events and multiple contingency events with the performance capability of generating units connected to the power system. Operating the power system outside of the normal operating band for periods in excess of ten minutes may increase the risk of generator failures and the subsequent risk of cascading failure.

While it may not be possible to restore the power system to within the normal operating band within ten minutes following all possible non-credible contingency events, the Panel consider that AEMO should use reasonable endeavours to attempt to do so. Although NER clause 4.2.6 (b) requires AEMO to take all reasonable action to restore the power system to a secure operating state within thirty minutes, the Panel considers that AEMO should also use reasonable endeavours to restore the power system frequency to within the NOFB within ten minutes as failure to do so is likely to increase the risk of failure of generating units which would negatively impact the restoration process, including an increased risk of cascading failure.

The obligation in the FOS to maintain power system frequency within the extreme frequency tolerance excursion limit has been replaced by a "reasonable endeavours" obligation which reflects the uncertainty associated with planning for non-credible and multiple contingency events. This revised requirement gives AEMO flexibility and discretion to assess the preferred approach to managing power system frequency risks, while maintaining the performance target for operation of the power system.

The Panel notes that AEMO's advice and submissions, indicate that AEMO does not consider it necessary for the FOS to contain a general obligation in relation to multiple contingency events. In determining the draft stage one standard, the Panel considers that this "reasonable endeavours" requirement for AEMO clarifies the expectations of reasonable operational practise following a multiple contingency event or non-credible contingency event and is consistent with the revised power system security principles mentioned above.

The Panel does not consider there is any basis for setting a requirement for specific multiple contingency events, as suggested by Energy Australia and ERM, as such an obligation would be covered under the declaration of a protected event, where it is economic to do so.

86 NER S5.2.5.3

Part B(g) of the FOS has also been revised to clarify the type of event that this requirement applies to. The revised wording expands on the reference to multiple contingency events in the current FOS to also include any non-credible contingency event or multiple contingency event that is not a protected event.

## 4.4 Revision of the definition of generation event

The FOS includes a revised definition of a generation event. The revised definition has been expanded to cover, "an event that result in the sudden, unexpected and significant increase or decrease in the *generation* of one or more *generating systems* of more than 50MW within a period of 30 seconds or less".

This change has been made to cover the sudden and unexpected increase or decrease of generation output from a generator, particularly as may occur from time to time from large scale solar PV farms, due to sudden change in climatic conditions, such as local cloud cover.

The definition of generation event in the FOS differs from that in the draft FOS through the inclusion of the words, "an event that results in". These words are included in the definition to clarify that the sudden, unexpected and significant increase or decrease in the generation must be as the result of some common causative event, such as unexpected cloud cover affecting a large scale solar farm or farms.

### 4.4.1 Current arrangements in the FOS

The Panel understands that historically, the current definition of a generation event in the FOS has been interpreted to cover the synchronisation of a generating unit of more than 50MW, or the tripping of a generating unit as the result of a credible contingency.[87] However, this interpretation has not extended to include the rapid variation of generation output of one or more generating units.

The existing definition of 'generation event' varies between the FOS for the mainland and the FOS for Tasmania.

The term "generation event" is defined in the mainland FOS as:

> "a synchronisation of a generating unit of more than 50 MW or a credible contingency, not arising from a network event, a separation event or a part of a multiple contingency event." [88]

And in the FOS for Tasmania as:

> "a synchronisation of a generating unit of more than 50 MW or a credible contingency event in respect of either a single generating unit or a transmission element solely providing connection to a single generating unit, not arising from a network event, a separation event or a part of a multiple contingency event."

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87 The Panel notes that the current definition of a generation event does not explicitly refer to generator tripping but instead to a "credible contingency not arising from network event, a separation event or a part of a multiple contingency event".

88 A synchronisation is defined in Chapter 10 of the NER as: "To electrically connect a generating unit or a scheduled network service to the power system."

In practise the Panel understands that these definitions have been interpreted to mean that a generation event for the purpose of the FOS for the mainland and Tasmania is either:

- the connection (synchronisation) of a generating unit of more than 50MW; or
- the disconnection of a generating unit as the result of a credible contingency that is not a network event, a separation event or a part of a multiple contingency event.

The Panel also understands that this interpretation has then informed AEMO's operational decisions in terms of management of the power system, including in terms of whether it classifies different generation events as credible contingency events, which in turn determines whether it manages the consequences of these events through the use of regulating or contingency FCAS.

AEMO has a responsibility to maintain the power system within the NOFB for normal operation conditions. To do this, AEMO uses regulating FCAS services to account for smaller changes in the balance of generation and load.

AEMO is also required to return the power system to a satisfactory operating state in accordance with the FOS, following the occurrence of any credible contingency or protected event.[89]

A credible contingency event is defined in the NER as a contingency event that is reasonably possible in the surrounding circumstances, an example of a credible contingency event is:[90]

> "the unexpected automatic or manual *disconnection* of, or the unplanned reduction in capacity of, one operating *generating unit*;"

Furthermore a contingency event is defined in the NER as:

> "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*."

As mentioned above, AEMO is required to return the power system to a secure operating state following a contingency event, in accordance with the FOS, and may use contingency FCAS to do so.

However, the Panel understands that there is some uncertainty as to whether the current FOS definition of generation event includes an event that results in the sudden unexpected variation of generation output, as may occur from large scale solar PV farms. It may therefore be unclear whether this event can be classified as a contingency event, or whether it should be considered as part of the normal operating conditions of the power system.

If AEMO faces uncertainty as to whether this kind of event can be reasonably classified as a credible contingency, it may not be clear as to whether it can address this event

89 NER clause 4.2.4(a)(2)

90 NER Clause 4.2.3(b)(1)

through the use of contingency FCAS, or whether it should be considered as part of more normal operating conditions, in which case its consequences would be managed through the use of regulating FCAS.[91]

### 4.4.2 Stakeholder views

**Submissions to the stage one draft determination**

The majority of stakeholder submissions support the revision of the definition of generation event as proposed in the draft FOS.[92] In relation to the management of generation variability in the powers system, Origin Energy noted that:

> "Allowing AEMO to utilise both Regulation and Contingency FCAS should enable lowest priced outcomes to be achieved."[93]

While Energy Australia expressed provisional support for the inclusion of variability of generation within the definition of a generation event, it also suggests that stage two of the review should further examine the increased likelihood of the occurrence of an event under this definition and the implications for the market.[94]

CS Energy provided a detailed and quantitative submission to the draft determination to make the case that the definition of generation event should not be changed to include the variation of generation output.[95] CS Energy asserted that:

- To date, events involving the variation of solar PV generation of greater than 50MW in less than 30 seconds are very rare and should be able to be managed by the regulation FCAS within the NOFB.[96]
- The effectiveness of regulation FCAS could be improved through refinement and upgrades to AEMO's AGC system to better manage system frequency during normal operation.[97]
- the use of Contingency FCAS in lieu of Regulation FCAS to manage this generation variability may dull the price signals that are associated with the allocation of regulation FCAS costs to market participants who are deemed to have caused the frequency deviations through their respective causer pays contribution factors.[98]

The Panel's response to this submission is included in section 4.4.3.

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91 The Panel notes AEMO's advice that the current definition of the generation event is unclear. AEMO *Advice to the Reliability Panel for the review of the frequency operating standard*, 18 August 2017, p.9.

92 Submissions top the draft determination: AEMO, p.4; ENA, p.2; Energy Australia, p.2. Origin Energy, p.1.

93 Origin Energy, Submission to the draft determination, p.1.

94 Energy Australia, Submission to the draft determination, p.2.

95 CS Energy, Submission to the Draft determination, pp.1-2.

96 Ibid. pp.6-10

97 Ibid. pp.14-53

98 Ibid. pp. 55-56.

**Submissions to the issues paper**

The majority of stakeholder submissions support the revision of the definition of generation event to account for and include sudden unexpected variation in generation output as may occur from large scale solar PV farms.[99]

In supporting the proposed revision of the definition of generation event to cover the large and unexpected changed in generation output from a generator or a set of generators AEMO noted that:

"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 103MW plant."[100]

The South Australian government suggested that the Panel also consider whether it would be appropriate for the definition of a generation event to be expanded to account for any single points of failure for all types of generation, such as the failure of a "transmission element solely providing connection to a single generating unit".[101]

TasNetworks recognise that the issues of solar PV ramping and high speed wind cut-out are issues that have a growing implication for frequency control in the NEM. TasNetworks stated that these events may be managed as part of normal operation, with regulating FCAS, or as contingency events, with contingency FCAS, depending on the regularity of such events and the availability and capability of regulating and contingency FCAS to effectively maintain the FOS.[102]

**AEMO Advice**

AEMO has provided the Panel with advice detailing the nature of the challenge relating to the management of large changes in generation output from over short time period, as may occur from solar PV during intermittently cloudy days. This advice supported the Panel's proposal to consider amendments to the definition of a generation event in the FOS and provided additional evidence detailing the benefits of changing this definition in terms increasing operational flexibility for AEMO and reducing the burden of regulating FCAS procurement relative to the do nothing approach.

Building on the information contained in AEMO's submission to the issues paper relating to the scale of variability observed for large scale solar PV farms, AEMO's advice noted that:[103]

> "AEMO's analysis suggests that utility scale PV variability is especially significant, and likely to lead to a significant increase in regulating FCAS required once 1-2 GW are installed."

And:

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99 Submission to the issues paper: ENA, p.4; Engie, p.5; Meridian Energy, p.3-4; ERM Power, p.4; AEMO, p.6; Department of the Premier and Cabinet - South Australia, pp.6-7.

100 AEMO, Submission to the Issues paper, 1 August 2017, p.6.

101 Department of the Premier and Cabinet - South Australia, Submission to the issues paper. pp. 6-7.

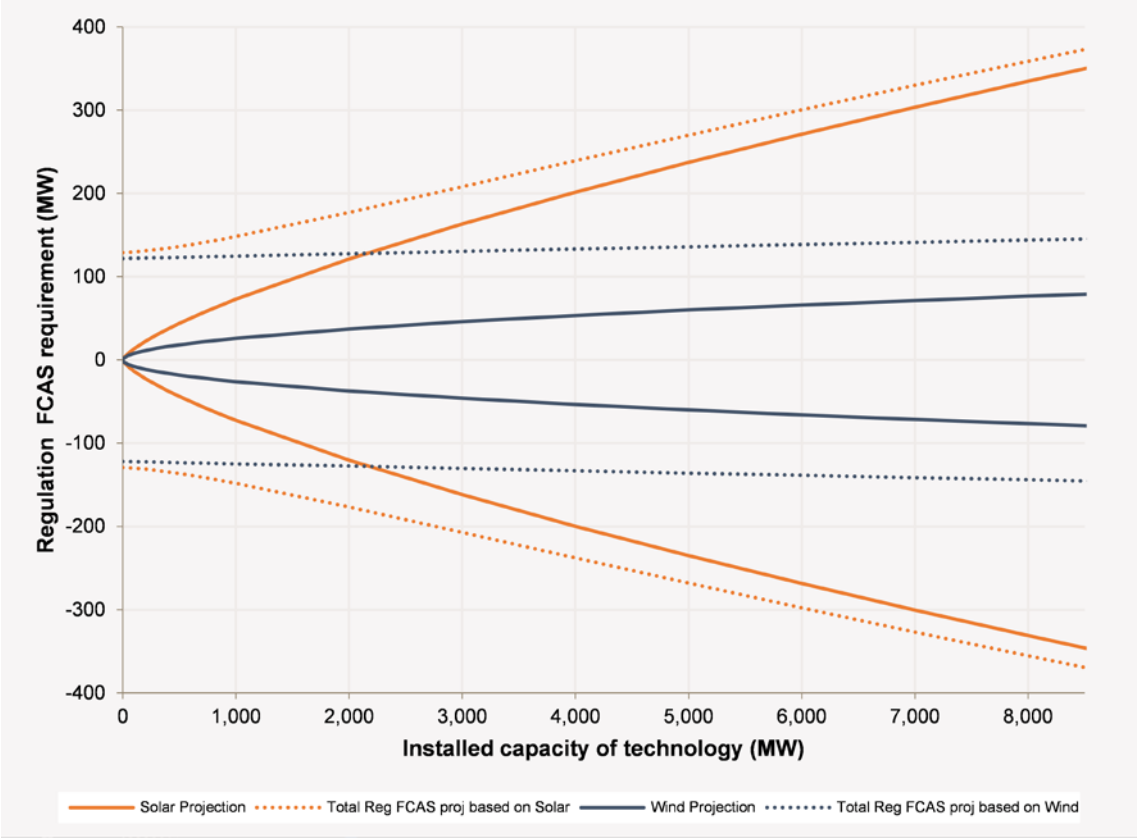
102 TasNetworks, Submission to the issues paper, p.12.

103 AEMO, *Review of the frequency operating standard*, stage 1 – request for advice, 18 August 2017, pp.7-11.

"If this change is not made, AEMO may be required to purchase additional regulating 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."

Figure 4.1 shows the results of AEMO's analysis that projects the quantity of regulating raise and regulating lower FCAS as a function of installed solar PV capacity in the NEM. This analysis shows a marked increase in the volume of both raise and lower regulating service required as the quantity of large scale solar generation increases in the NEM.

**Figure 4.1 Required Regulating FCAS Vs installed Solar PV capacity – mainland NEM[104]**




AEMO considered that management of this kind of increased variable generation output through the use of contingency FCAS will help to minimise FCAS costs over the near term, until such time as the size of variable renewable generation power stations exceed that of the largest generating units that currently operate in the NEM.[105]

104 AEMO, Advice to the Reliability Panel for the review of the frequency operating standard, 18 August 2017, p.10.
Note: that these projections are indicative only, as they depend on limited data and assume no material changes to solar farm behaviour or systematic improvements in forecasting.

105 This is because by "transferring" management of the consequences of these kinds of events from regulation to contingency FCAS, it may be possible to reduce the volume of regulation FCAS procured, while managing the consequence of these events through the contingency FCAS that has

In terms of the size threshold against which the variation of generation is measured, AEMO supported the application of the current 50MW threshold as the lower limit for the unexpected variation of generation output. However, AEMO also noted that this value of 50MW may need to be subject to a more detailed review to assess its ongoing appropriateness in relation to the nature of the power system.[106]

For the time element of this threshold, AEMO propose that:[107]

> "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)."

In proposing a maximum time limit of 30 seconds, AEMO recognised that due to the functional limitations of existing equipment, the response capability of regulating FCAS to manage variation of generation output of over 50 MW is effectively limited to a minimum response time in excess of 30 seconds. AEMO's advice was that contingency FCAS is more suited to respond to variation of generation output of over 50 MW within a time period less than 30 seconds, therefore the time limit for the variation of generation output should be less than or equal to 30 seconds.

AEMO regard this change as a high priority that will realise immediate operational and economic benefit for the NEM:[108]

> "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."

The Panel also notes AEMO's suggested definition for a generation event:[109]

> "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".

The Panel notes that in suggesting this definition of generation event, AEMO effectively argued that the existing NER definition of a contingency event may already allow for the rapid change in generation from a generating unit to be defined as credible contingency event.[110] Accordingly, AEMO proposed that to allow it to address this rapid change in output as a contingency event, the FOS should point clearly to the existing NER clauses that describe contingency events and credible contingency events.

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already been procured to manage the largest contingency. This may result in an reduction in the aggregate volume of regulation and contingency FCAS procured. Currently, the largest credible generation contingency in the NEM is frequently the loss of the CS Energy - Kogan Creek unit, which has a rated capacity of 744 MW.

106 AEMO, Advice to the Reliability Panel for the review of the frequency operating standard, 18 August 2017, p.8.

107 AEMO, Advice to the Reliability Panel for the review of the frequency operating standard, 18 August 2017, p.8.

108 Ibid, p.11.

109 Ibid. p.9.

110 Ibid.

### 4.4.3 Panel considerations in relation to the definition of generation event

The Panel considers that this issue identified by AEMO is likely to have material consequences, if left unaddressed. However, it also considers that the solution proposed in AEMO's advice will not provide sufficient certainty and clarity in terms of how the frequency consequences of these rapid variations in generator output should be managed.

Accordingly, the Panel has set out changes to the definition of generation event in the FOS that clearly define the kinds of events that AEMO should include in its consideration of a generation event, to include the rapid variation of output from generating systems within a 30 second time period.

**Materiality of issue**

As evidenced in table 4.1 below, the Panel is aware that there is a large quantity of new large scale solar PV generation capacity scheduled to be connected to the NEM power system over the next twelve months. As noted by AEMO, the particular characteristics of large scale solar PV mean that this generation may be particularly likely to exhibit large swings in output in relatively short periods of time.

Table 4.1 shows a summary of all operational and committed large scale solar PV generation with a generator capacity of over 50MW. This table shows that installed large scale solar PV capacity, from plants larger than 50MW, will grow by 640MW over the next twelve months, from the current 211MW, reaching 851MW by August 2018.

The Panel notes the increase in the maximum plant size from the current 102MW at Nyngan solar farm to 150MW with the connection of the Clare Solar Farm in Queensland in summer 2017/18 and 220MW with the connection of the Bungala Solar Power Project in South Australia in August 2018.

**Table 4.1 Snapshot of upcoming and existing large scale solar PV generation (>50MW)[111]**

| NEM Region | Plant Name | Commercial Use Date | Nameplate Capacity (MW) |
|---|---|---|---|
| Victoria | Gannawarra Solar Farm | April 2018 | 50 |
| South Australia | Bungala Solar Power Project | August 2018 | 220 |
| Queensland | Clare Solar Farm | Summer 2017/18 | 150 |
| | Hamilton Solar Farm | March 2018 | 57.5 |
| | Whitsunday Solar Farm | March 2018 | 57.5 |
| NSW | Broken Hill Solar Plant | In service | 53 |

111 AEMO, Generation information, 5 June 2017. https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information

| NEM Region | Plant Name | Commercial Use Date | Nameplate Capacity (MW) |
|---|---|---|---|
| | Moree Solar Farm | In service | 56 |
| | Nyngan | In service | 102 |
| | Manildra Photovoltaic Solar Farm | Winter 2018 | 50 |
| | Parkes Solar Farm | Summer 2017/18 | 55 |
| **Total existing large scale solar PV generation greater than 50MW** | | | **211** |
| **Total committed large scale solar PV generation greater than 50MW** | | | **640** |

The Panel recognises the potential operational challenges presented by the expected increase in large scale solar PV generation, given AEMO's analysis of the potential impacts on variable generation output from increased large scale solar penetration.

The Panel also considers that these challenges may at least in part reflect the current uncertainty as to how the current FOS definition of generation event has been interpreted, specifically in terms of how this definition has been translated into operational practices.

**Response to the CS Energy Submission to the draft determination**

The Panel appreciates the quality of analysis that CS Energy presented in its submission and recognises the sudden variations of generation output of the type addressed by this change to the FOS are, currently, rare events.

Under the current frequency control frameworks, AEMO is limited to the use of regulation FCAS for the purposes of maintaining the power system frequency within the NOFB. However, AEMO's advice is that the regulation services are not able to respond effectively to correct the rapid frequency changes caused by the variation of generation output as can occur from large scale solar PV power stations. [112]

This is supported by the recently published frequency diagnostic report prepared for AEMO by DIgSILENT, *Review of Frequency Control Performance in the NEM under Normal Operating Conditions*. The report comments on the functionality of the AGC as a secondary frequency control system:[113]

> "The AGC is not a suitable control system to manage higher frequency oscillations within the NOFB, or fast changes to frequency on the power system."

Therefore, this change to the definition of generation event in the FOS aligns with the current capabilities of the AGC controlled regulation services as well as expectations for

112 AEMO, Advice to the Reliability Panel for the review of the frequency operating standard, 18 August 2017, p.8.

113 DIgSILENT, *Review of Frequency Control Performance in the NEM under Normal Operating Conditions* – final report prepared for AEMO, 19 September 2017.

managing the power system within the operational realities of the current frequency control frameworks.

Under the current arrangements, many instances of generation variability will continue to be managed within the normal operating band. However, for the reasons set out above, the Panel does not consider it reasonable to expect the existing AGC and regulation services to manage the kinds of rapid change events described above without assistance of fast response services such as from contingency FCAS.

Furthermore, it is likely that managing the variability of generation, particularly these kinds of rapid change in output will become more difficult with the expected increase in large scale solar PV capacity, as discussed in section 4.4.3.

The Panel notes that the broader issue of frequency control during normal operation including the suitability of the current frequency control arrangements for dealing with increased variability of supply and demand in the power system is being considered by the AEMC through the *Frequency control frameworks review*.[114]

**Implications of uncertainty regarding the FOS**

The Panel considers that the existing definition of generation event in the FOS is insufficiently clear, in that it does not explicitly account for rapid variation of output from a generating unit or generating system. Consequently, as noted above, the current wording of the FOS has typically been interpreted to refer solely to events such as a generator synchronisation or trip.

The Panel understands that this has resulted in AEMO managing any rapid variations in generation output (particularly from large scale solar PV power stations) through the deployment of regulating FCAS coordinated through AEMO's centrally managed automatic generation control system, as opposed to being managed through contingency FCAS.

The Panel considers that under the current definition of generation event this increase in the maximum size and the total installed capacity of large scale solar PV generation is likely to drive an increase in the quantity and cost of regulating FCAS procured by AEMO to offset the expected variation in generation output and associated frequency excursions. However, in some instances, it may be more efficient to rely on contingency FCAS to address the frequency consequences of these kinds of events.

The definition in the FOS of a generation event has therefore been revised to explicitly include these kinds of rapid unexpected variation of generation output. The Panel consider that this will provide increased clarity in terms of allowing AEMO to manage the consequences of these events through the use of contingency FCAS, rather than relying solely on regulating FCAS.

The Panel understands that while this may allow for these kinds of events to result in broader frequency excursions, it will also allow AEMO to use contingency FCAS to rebalance the power system, in the event that the unexpected variation of generation output exceeds the threshold of 50MW within a 30 second period.

114 AEMC, *Frequency control frameworks review* – Issues Paper, 7 November 2017.

The size threshold for this generation event is supported by AEMO's advice to the Panel and is equal to the size limit for the synchronisation of a generation unit from previous iterations of the FOS for the mainland and for Tasmania. The 30 second time limit within which the variation of generation output must occur is based on AEMO's advice and the response time for regulating FCAS, via the AGC system.[115]

The Panel understands that, over the next couple of years, this revision is not expected to drive a material change in the quantity of contingency FCAS procured in the NEM under normal operating conditions. The basis for this is that the quantity of contingency FCAS purchased in each dispatch interval is set in order to mitigate the largest single credible contingency event. This credible contingency may involve the failure or disconnection of a one transmission element or a single generating unit[116]. Currently the single largest generating unit in the mainland NEM is the 744 MW Kogan Creek steam turbine operating by CS Energy in Queensland.

However the Panel understands that over the longer term the size of large scale solar PV generating systems is expected to increase, as supported by the recent announcement of plans by Equis to build a 1000MW solar PV farm over the next four years near Wandoan in Queensland.[117] With this in mind the Panel will consider the long term costs and benefits of this definition of generation event and the associated threshold of 50MW as part of stage two of the review of the FOS.

The Panel also recognises that in many cases, the entry of new generation may occur in clusters, that is, with multiple generating systems locating in the same area. This might include several small solar farms locating at a single location where there is both network capacity available as well as strong solar resource. These individual solar farms are likely to exhibit the same rapid changes in generation output, as they will all be affected by the same climatic conditions.

In order to allow for the effective management of the impacts of these kinds of small, co-located variable generators, the definition of generation event for the stage one FOS refers to a total capacity of generating systems being equal to or greater than 50MW. This will allow for AEMO to manage the frequency impacts of these kinds of generators through the use of contingency FCAS.

## 4.5 Revision of the definitions in the FOS related to island operation

The definition of an island has been revised for the purpose of application of the FOS for island operation following a separation event. This new definition of "island" replaces the current terms "electrical island" and "abnormal frequency island" as used in the mainland FOS. This revised definition maintains the key elements of the existing definition of an island with the addition of the requirement, that an island must be at least the equal to or greater than an inertia sub-network.

The definition of an island in the FOS is:

115 AEMO, *Review of the frequency operating standard*, stage 1 – request for advice, 18 August 2017, pp.8.

116 NER clause. 4.2.3(b)

117 Toowomba Chronicle, 1000 megawatt Equis Energy solar farm approved in western Queensland, 4 August 2017.

"a part of the *power system* that includes *generation*, *networks* and *load*, for which all of its alternating current 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 combined *generation* of each of two *regions* (determined by available capacity before disconnection); and

(b) contains at least one whole *inertia sub-network*."

The definition of an inertia sub-network is included in the FOS as:

"has the meaning given to it in the Rules."

These definitions apply to both the FOS for the mainland and for Tasmania as set out in Appendix A.3.

### 4.5.1 Current definitions in the FOS related to Island operation

In the current FOS for Tasmania, the definition of an "island" is as follows:

> "means a part of the Tasmanian power system that includes scheduled generation, networks and load for which all of its alternating current network connections with other parts of the power system have been disconnected"

In the FOS for the mainland NEM the term "island":

> "means either an electrical island or an abnormal frequency island."

The definition of an "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 does not include more than half of the generation of each of two regions (determined by available capacity before disconnection)."

and an "abnormal frequency island":

> "means a part of the power system that includes generation, networks and *load* for which all of its alternating current network connections with other parts of the power system have been disconnected, provided that the part does not include more than half of the generation of each of two *regions (determined by available capacity before disconnection)."*

The difference between an electrical island and an abnormal frequency island is that for an electrical island all network connections have been disconnected, whereas for an abnormal frequency island all alternating current network connections have been disconnected but any DC interconnections could still be operating. The result is that an abnormal frequency island may still be connected to the remainder of the power system by one or more direct current network elements, allowing power transfer but not a common frequency. An example of this is the separation of the South Australian region through the disconnection of the Heywood interconnector, where the Murraylink DC interconnector remains connected. The resultant South Australian island would be an abnormal frequency island as defined in the current FOS.

### 4.5.2 Stakeholder views

**Submissions to the stage one draft determination**

The majority of submissions to the draft determination approved of the proposed definition of "island" as set out in the draft FOS.[118]

**Submissions to the issues paper**

The majority of stakeholder submissions to support the clarification of the characteristics of an island for the purpose of island operation as set out in the FOS.[119]

In supporting the principle to clarify the characteristics of an island for the FOS TasNetworks noted that:[120]

> "The basic characteristics of a viable electrical island are considered the same as for intact operating conditions and revolve around the need for stable frequency and voltage control as well as the continued operability of protection systems that ensure the safety of people, plant and network equipment."

TasNetworks also raised a number of additional considerations in their submission that relate to island operation, including:[121]

a) Whether a viable island should capable of withstanding any single credible contingency event (often referred to as N-1)?

b) Whether an island formed due to a protected event should be more resilient than an island involving a small sub-section of a single NEM region?

c) Whether AEMO's market systems have the ability to control scheduled generating units for an island that forms within the Tasmanian region?

d) Whether an island that does not meet the requirements set out in the FOS can be retained in service for a period of time to allow network customers to transition to alternate energy supplies, such as back-up generation?

The Panel's consideration on items a) and b) are incorporated below in section 4.5.3. The Panel notes that items c) and d) are issues related to operation of the power system and are best resolved through a collaborative approach by AEMO and TNSP's.

**AEMO Advice**

AEMO's advice supports the proposed revision of the definition of an island for the FOS, including inclusion of the linkage to an inertia sub-network. AEMO notes that:[122]

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118 Submissions to the draft determination: AEMO, p.4; ENA, p.2; Origin Energy, p.1.

119 Submissions to the issues paper: ENA, p.3; SACOSS, p.1; Engie, pp. 4-5; Meridian Energy, p. 3; TasNetworks, p. 6; ERM Power, pp.3-4; AEMO, p. 5; Hydro Tasmania, p. 1; Department of the Premier and Cabinet - South Australia, p. 6.

120 TasNetworks, Submission to the issues paper, pp.6-7.

121 Ibid. p.7.

122 AEMO, Advice to the Reliability Panel for the review of the frequency operating standard, 18 August 2017, p.4.

"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."

### 4.5.3 Panel's considerations for definitions associated with island operation

The Panel has reduced the complexity of the definitions that relate to island operation by setting one definition of an island that applies for both the mainland FOS and the Tasmanian FOS. In addition the definition of an "island" in the FOS replaces the previous terms of "electrical island" and "abnormal frequency island" as used in the current FOS for the mainland.

The Panel considers that for the purpose of frequency control, there is no difference between an "electrical island", where all network connections are disconnected and an "abnormal frequency island" where all alternating current network connections are disconnected.[123] For this reason the stage one FOS does not include the terms "electrical island" and "abnormal frequency island".

The Panel recognises that the island operation FOS should only apply to an island within the power system which is capable of being operated independently following a separation event. Therefore the FOS includes revised definitions which provide additional clarity as to the minimum size of an island for the purpose of island operation in accordance with the FOS.

The Panel considers that the basic goal of island operation is the same as the goal for operation of the power system as a whole, which is that the sub-network forming the island must be capable of being returned to and maintained in a secure operating state following the separation event that caused the islanding. A "secure operating state" is defined in the NER as being the satisfaction of the following two conditions:[124]

1. The system parameters, including frequency, voltage and current flows are within the operational limits of the system elements, referred to as a "satisfactory operating state"
2. The system is able to recover from a credible contingency event or a protected event, in accordance with the power system security standards.

It may be difficult for AEMO to maintain a secure operating state for any part of the power system that is islanded, as certain islanded portions of the network may not be capable of being operated independently as viable islands.

The issue of the ability for an islanded system to be operated independently was discussed as part of *Managing the rate of change of power system frequency* rule change. The final rule includes a new power for AEMO to determine inertia sub-networks and criteria for assessing the viability for the independent operation of those sub-networks

123 As frequency is only shared through AC network connections, not through DC network connections. If an island is formed with a DC network connection still in operation the DC connection acts in the electricity and FCAS markets in a similar way to a generator, by offering energy and FCAS through the DC connection. An example of this is the Basslink interconnector connecting the mainland NEM with Tasmania.

124 NER Rule 4.2.2 and Rule 4.2.4

(with interim inertia sub-networks being deemed to be the regional boundaries). This rule will take effect from 1 July 2018. Clause 5.20.B.1(d) of the final rule specifies that: [125]

> "in determining and adjusting the boundaries of *inertia sub-networks*, AEMO must take into account the following matters:
>
> (1) synchronous connections between the proposed *inertia sub-network* and adjacent parts of the *national grid*;
>
> (2) the likelihood of the proposed *inertia sub-network* being *islanded*; and
>
> (3) the criticality and practicality of maintaining the proposed *inertia sub-network* in a *satisfactory operating state* if it is *islanded* and being able to return to a *secure operating state* while *islanded*."

The Panel considers these requirements set out in the *Managing the rate of change of power system frequency* draft rule align closely with the requirements for defining the lower limit of an islands for the maintenance of the FOS. Therefore, the revised definitions of electrical island and abnormal frequency island in the FOS include the new requirement that the resultant sub-network "is at least equal to or greater than an inertia sub-network." This requirement enables an island for the purpose of maintaining power system frequency in accordance with the FOS to be larger than an inertia sub-network but not smaller.

Under this definition of an island, AEMO would not be required to maintain the FOS for a separated portion of the network that did not contain at least one whole inertia sub-network, as it would not be practical to do so. However where an island forms that does contain at least one whole inertia sub-network the FOS for island operation would apply, including the relevant normal operation and contingency frequency bands. The Panel recognises that this definition of an island in the FOS is not linked to the likelihood of an island forming through the occurrence of a contingency event, including a protected event. The Panel consider that the *Managing the rate of change of power system frequency* draft rule requires AEMO to take into account the likelihood of the proposed sub-network being islanded, which will include the nature of the event that may form the island.[126]

## 4.6 The limit for accumulated time error in the FOS

The Panel has increased the limit for accumulated time error in the mainland FOS from 5 to 15 seconds. The limit of accumulated time error in the FOS for Tasmania remains unchanged at 15 seconds.

The Panel's initial consideration is that there may be a case for the complete removal of the accumulated time error limit. However, there is some possibility that the removal of this time error limit could have unforeseen impacts on large and small consumers. In order to limit the risk, the Panel has decided to initially relax the accumulated time error limit, with a view to full removal once consultation has been undertaken with a wider range of consumers.

125 AEMC, *Managing the rate of change of power system frequency* - rule, 19 September 2017. Clause. 5.20B.1.

126 AEMC, *Managing the rate of change of power system frequency* - rule, 19 September 2017. Clause. 5.20B.1.

The Panel will continue to consult with stakeholders in relation to the intention to remove the accumulated time error limit from the FOS through the course of stage two of this review.

### 4.6.1 Current requirements of the FOS

Accumulated time error is the cumulative sum of the difference between the actual power system frequency over time and the nominal system frequency of 50Hz.[127]

The FOS currently requires AEMO to limit the accumulated time error related to the power system frequency to:

- 5 seconds for the mainland NEM
- 15 seconds for Tasmania

Historically, limiting accumulated time error was important to maintain accurate time keeping when synchronous clocks that depended on the power system frequency were common place. The Panel understands that the reliance on synchronous clocks has diminished in recent times and that limiting the accumulated time error does not improve the reliability or security of the power system.[128]

### 4.6.2 Stakeholder views

**Submissions to the stage one draft determination**

The majority of stakeholder submissions support the relaxation of the limit on accumulated time error that applies for the mainland NEM.[129]

While Origin Energy supports the relaxation of the limit on accumulated time error for the mainland NEM, their submission suggests that that the removal of the limit during stage two would be potentially premature and that:

> "A longer evaluation period, (e.g. until the next FOS review) would allow for the effects of the time error change to be evaluated, thus giving a clearer view of potential removal and overall ensuring minimal impact on participants."[130]

On the other hand, CS Energy argued in its submission that the limit on accumulated time error should not be changed. CS Energy suggest that the time error limit is acting as a "canary in the coal mine" to identify poor frequency performance in the power system. CS Energy suggest that the operation of regulation FCAS and the AGC system could be improved to improve power system frequency performance and limit the accumulation of time error and associated time error correction.[131]

**Submissions to the issues paper**

127 See Reliability Panel, *Review of the frequency operating standard* – issues paper, 11 July 2017, pp.14-15, 42-43.

128 Ibid.

129 Submissions to the draft determination: AEMO, p.4; ENA, p.2; Meridian Energy, p.1; Origin Energy, p.1.

130 Origin Energy, Submission to the draft determination, p.1.

131 CS Energy, Submission to the draft determination, pp.49-50.

The majority of stakeholders support the relaxation or removal of the requirement in the FOS for AEMO to limit accumulated time error.[132]

ERM Power indicated that they are not aware of any issue that would impact the operation of Oakey Power Station as a result of the removal of a limit on accumulated time error.[133]

Engie explained in their submission that the removal of accumulated time error from the FOS may help resolve an issue relating to market participants finding it hard to reconcile FCAS causer pays outcomes. Currently frequency control and the causer pays mechanism is based on a frequency error and a time error (integral) component. The removal of a limit on accumulated time error may allow for the simplification of this element of the causer pays mechanism and improve transparency for market participants.[134]

A number of stakeholders indicated their support for the removal of an obligation to limit accumulated time error while also supporting the maintenance of the reporting of accumulated time error as a measure of power system frequency performance.[135]

**AEMO advice**

AEMO's advice to the Panel supports the removal or relaxation of the requirement to limit accumulated time error as a largely unnecessary obligation. AEMO's investigations indicate that there are no system security (or reliability) benefits from conducting time error correction. In terms of the potential impact on electricity customers from the removal of the limit on accumulated time error, AEMO state that:[136]

> "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."

AEMO's indicates that the removal of the limit on accumulated time error, and corresponding cessation of time error correction, may reduce the quantity and cost of regulating FCAS by as much as 1% per annum, representing approximately $1million in FCAS costs.[137]

AEMO's analysis of the recent power system frequency performance have also identified time error correction as a process that occasionally acts contrary to the frequency control goals for the power system. This is described further in section 4.6.3.

While AEMO supports the removal of accumulated time error in principle, they recognise the need for stakeholders to be given adequate opportunity to engage with

132 Submissions to the issues paper: SACOSS, p.1; Engie, p.5; Meridian Energy, p.3; ERM Power, p.4; AEMO, p6-7; PIAC, p.1.

133 ERM Power, Submission to the issues paper, p.4.

134 Engie, submission to the issues paper, p.5.

135 Submissions to the issues paper: ENA, p.4; TasNetworks, p.8; HydroTasmania, p.1.

136 AEMO, Advice to the Reliability Panel for the review of the frequency operating standard, 18 August 2017, pp.5-7.

137 Ibid.

this issue, to understand the implications and provide feedback where necessary. As such AEMO supports a phased approach to the removal of time error correction, with the aim to finalise its removal in stage two of the review of the FOS.[138]

### 4.6.3 Panel's considerations for accumulated time error

This section outlines the Panel's considerations in relation to the costs and benefits of the practise of time error correction in the NEM, where time error correction is the operational process used to limit accumulated time error in accordance with the limit set in the FOS.

This forms the basis for:

- The relaxation of the limit on accumulated time error that applies in the FOS for the mainland NEM to be equal to the limit that applies in the Tasmanian FOS of 15 seconds.
- The potential for the ultimate removal of the obligation to limit accumulated time error from the FOS for the mainland and for Tasmania through the course of stage two of the review.

During the course of stage two, the Panel will also consider whether there is a benefit in maintaining some form of reporting function in relation to accumulated time error as a measure of frequency performance, and in what form such a reporting function may take.

Throughout the coming months, the Panel intends to consult with industry and customer representatives in relation to the intention to remove the limit on accumulated time error. The Panel is keen to hear from interested parties, particularly smaller consumers, in relation to this proposed change to the FOS.

**The purpose of time error correction**

Historically, time error correction was used to maintain the frequency of the power system within defined limits. The purpose of this was to support various pieces of consumer equipment that included time keeping devices, where the mechanism of time keeping was the power system frequency itself. The practice of time error correction of the power system frequency was necessary to keep these synchronous clocks accurate.

While some household appliances may use synchronous clocks for time keeping, the Panel understands that it is now rare for industrial processes to rely on the use of synchronous clocks for time keeping. Digital clocks based on quartz crystal resonators are now the standard mechanism for accurate time keeping.

**Regulating FCAS and time error correction**

During normal operation, the power system frequency is maintained within the NOFB by regulating FCAS. The primary purpose of regulating FCAS is to correct small frequency deviations away from 50Hz.[139] However, in order to comply with the limit

138 Ibid.

139 AEMO, Fact Sheet-Frequency Control, 8 August 2016. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/AEMO-Fact-Sheet_Frequency-Control---Final.pdf

on accumulated time error, regulation FCAS is also used to perform time error correction, separate from any real time frequency correction. Time error correction is the process of manipulating the power system frequency up or down by a small amount for the purpose of reducing any accumulated time error that may build up as a result of the power system frequency deviating away from 50Hz form some time.

Box 4.2 provides a description of how time error correction operates in in the NEM.

**Box 4.2 Time error correction in the NEM**

In the NEM, time error correction is coordinated automatically by AEMO's Energy Management System (EMS), which monitors the power system frequency and coordinates the operation of regulating FCAS through automatic generation control (AGC) signals. The EMS tracks the system frequency and any accumulated time error and sends signals to generators enabled to provide regulating FCAS in order to correct small frequency deviations and reduce the value of any accumulated time error in accordance with the limits in the FOS.[140]

There are two variables determined by AEMO's systems which relate to time error correction:

- the required quantity of regulating FCAS purchased in each 5 minute dispatch interval
- the target power system frequency.

For Tasmania the quantity of regulating FCAS is set at a constant level of 50MW.[141] For the mainland NEM , the quantity of regulating FCAS varies between a base value of 130 MW for raise services and 120 MW for lower service and a maximum of 250MW depending on the cumulative time error.[142]

In the absence of time error correction the target power system frequency set by the EMS is equal to 50.00Hz. The practise of time error correction involves the modification of this target power system frequency in order to reduce any accumulated time error in accordance with the limits in the FOS for Tasmania and the mainland. To correct a positive accumulated time error, the target frequency is set below 50 Hz, while to correct a negative time error the target frequency is set above 50Hz. The Panel understands that, depending on the size of the accumulated time error, the target frequency may vary between 49.95 and 50.05 Hz.

AEMO's advice to the Panel indicates that it is likely that the benefits of limiting accumulated time error no longer justify the costs associated with the practise of time

142 AEMO, *Constraint Implementation Guidelines for the National Electricity Market*, June 2015, p. 27.

142 AEMO, *Constraint Implementation Guidelines for the National Electricity Market*, June 2015, p. 27. AEMO, *SO_OP_3715---Power System Security Guidelines*, 15 May 2017, p.47.

error correction, subject to satisfactory consultation to fully understand and evaluate any impacts on customers.[143]

**The costs of time error correction**

There are a number of costs associated with the practise of time error correction, including:

- increased quantity of regulating FCAS
- system security implications as a result of small changes to AEMO's control system target frequency while time error correction is operating

*Increased regulating FCAS*

As set out in box 4.2, AEMO varies the quantity of regulating FCAS procured for the mainland in response to the size of the accumulated time error. This practise can be in part attributed to an appropriate approach to managing the power system frequency, i.e. as the frequency diverges away from 50Hz for a longer period, the accumulated time error builds up and the quantity of regulating FCAS is increased (up to a limit of 250MW) to increase the size of the control response.

However once the real frequency error is corrected, an accumulated time error may remain, at which point the additional regulating FCAS is no longer performing a frequency control function, rather it is performing time error correction.

AEMO's advice is that the value of this additional regulating FCAS purchased for the purpose of time error correction on the mainland may be as much as $1 million per annum, based on data from January 2016 to June 2017.[144]

The purchase of additional regulating FCAS for time error correction is also likely to increase the price of regulation FCAS enabled through the FCAS markets. This was identified by DIgSILENT as a contributing factor in the withdrawal of voluntary governor frequency response within the normal operating frequency band.[145] In the context of this, DIgSILENT noted :

> "The Reliability Panel, who has responsibility for frequency standards, could consider whether time error correction is required in the twenty-first century."[146]

The broader issues relating to frequency control, including the provision of primary governor response, are being considered by the *Frequency control frameworks review*. However the Panel considers that the increase of the limit on accumulated time error for the mainland will allow AEMO more flexibility as to the timing and operation of time error correction which is likely to lead to a reduction in the price of regulation FCAS and a weakening of the effect noted above by DIgSILENT.*System security considerations*

143 AEMO, Advice to the Reliability Panel for the review of the frequency operating standard, 18 August 2017, p.7.

144 Ibid. p.5.

145 DIgSILENT, *Review of Frequency Control Performance in the NEM under Normal Operating Conditions* – Final Report prepared for AEMO, 19 September 2017, p.43.

146 Ibid.p.44.

AEMO's advice to the panel is that time error correction does not provide any system security or reliability benefits.[147] AEMO's analysis suggests that approximately 20% of the time that time error correction is being undertaken, it is actually mildly degrading power system frequency control. This degradation occurs when the time error correction target frequency is counter to the actual frequency goal.

For example, a positive time error is corrected by running the power system at slightly below 50Hz for a period of time, as described in Box 4.2. If at the same time, a contingency event occurs that results in a temporary shortage of generation in the power system the power system frequency will fall, and due to the operation of time error correction, fall from a lower starting point. As a result, by the time the frequency deviation is arrested, the frequency may have diverged further from 50Hz, than if time error correction were not being undertaken.[148] This counter acting frequency control is likely to place a heavier load on contingency FCAS and may result in an increased likelihood of the power system frequency diverging outside the operational frequency tolerance band, which would result in automatic load shedding.

The Panel notes CS Energy's proposition that the limit on accumulated time error may be acting dynamically to help correct for poor frequency regulation during normal power system operation.[149] This relates to the broader issue of what constitutes "good frequency control" and the appropriate mechanisms for achieving better frequency performance which are being addressed by the AEMC through the *Frequency control frameworks review*.[150]

In summary, the practise of time error correction is understood to be unnecessary as there are not understood to be any direct benefits, while there are mild economic and system security costs. As a result the Panel is relaxing the limit on accumulated time error that applies in the mainland to 15 seconds, in line with the current limit that applies in the Tasmanian FOS. Subject to the outcomes of the *Frequency control frameworks review,* the Panel will consider the removal of a limit on accumulated time error as part of stage two of the review of the FOS.

## 4.7 Arrangements for implementation of the Standard

The FOS published with this determination will take effect from 14 November 2017.

Following the completion of stage two of the review the Panel may publish a subsequent FOS that may replace this version.

147 AEMO, Advice to the Reliability Panel for the review of the frequency operating standard, 18 August 2017, p.6.

148 Ibid. pp.6-7

149 CS Energy, Submission to the draft determination, pp.49-50.

150 AEMC, *Frequency control frameworks review* – issues paper, 7 November 2017.
This review is also considering whether a reporting obligation for frequency performance metrics would be of benefit to market participants and general power system operation.

## Abbreviations

| | |
|---|---|
| AC | alternating current |
| AGC | automatic generation control |
| AS-TAG | Ancillary Services Technical Advisory Group |
| DC | direct current |
| EFCS | emergency frequency control schemes |
| ESCOSA | Essential Services Commission of South Australia |
| FCAS | frequency control ancillary services |
| FFR | fast frequency response |
| FOS | frequency operating standards |
| GW | Giga-Watt |
| MW | Mega-Watt |
| NEL | National Electricity Law |
| NEM | National Electricity Market |
| NEMDE | National electricity market dispatch engine |
| NEO | National Electricity Objective |
| NER | National Electricity Rules |
| TNSP | transmission network service provider |

# A The frequency operating standard

The Panel has made a determination to amend, in accordance with clause 8.8.3(a)(1) of the Rules and section 38 of the NEL, the NEM Mainland frequency operating standards which form part of the *power system security standards*. These amendments are contained in this Appendix A. This standard is effective from 14 November 2017.

## A.1 Frequency operating standards for the mainland NEM

### A.1.1 Part A Summary of the Frequency operating standards for the mainland NEM

The NEM Mainland *frequency operating standards* set out in Part B are summarised in the following tables for convenience. To the extent of any inconsistency between these tables and Part B below, Part B prevails. The following table applies to any part of the NEM Mainland *power system*, other than an *island* or during periods of supply scarcity during load restoration:

**Table A.1.1 NEM Mainland Frequency Operating Standards – interconnected system**

| Condition | Containment | Stabilisation | Recovery |
|---|---|---|---|
| Accumulated time error | 15 seconds | n/a | n/a |
| No contingency event or load event | 49.75 to 50.25 Hz,<br>49.85 to 50.15 Hz - 99% of the time | 49.85 to 50.15 Hz within 5 minutes | |
| Generation event or load event | 49.5 to 50.5 Hz | 49.85 to 50.15 Hz within 5 minutes | |
| Network event | 49 to 51 Hz | 49.5 to 50.5 Hz within 1 minute | 49.85 to 50.15 Hz within 5 minutes |
| Separation event | 49 to 51 Hz | 49.5 to 50.5 Hz within 2 minutes | 49.85 to 50.15 Hz within 10 minutes |
| Protected event | 47 to 52 Hz | 49.5 to 50.5 Hz within 2 minutes | 49.85 to 50.15 Hz within 10 minutes |
| Multiple contingency event | 47 to 52 Hz<br>(reasonable endeavours) | 49.5 to 50.5 Hz within 2 minutes<br>(reasonable endeavours) | 49.85 to 50.15 Hz within 10 minutes<br>(reasonable endeavours) |

**Table A.1.2 NEM Mainland Frequency Operating Standards – island system**

| Condition | Containment | Stabilisation | Recovery |
|---|---|---|---|
| No contingency event, or load event | 49.5 to 50.5 Hz | | |
| Generation event, load event or network event | 49 to 51 Hz | 49.5 to 50.5 Hz within 5 minutes | |
| The separation event that formed the island | 49 to 51 Hz or a wider band notified to AEMO by a relevant Jurisdictional Coordinator | 49.0 to 51.0 Hz within 2 minutes | 49.5 to 50.5 Hz within 10 minutes |
| Protected event | 47 to 52 Hz | 49.0 to 51.0 Hz within 2 minutes | 49.5 to 50.5 Hz within 10 minutes |
| Multiple contingency event including a further separation event | 47 to 52 Hz<br>(reasonable endeavours) | 49.0 to 51.0 Hz within 2 minutes<br>(reasonable endeavours) | 49.5 to 50.5 Hz within 10 minutes<br>(reasonable endeavours) |

**Table A.1.3 NEM Mainland Frequency Operating Standards – during supply scarcity**

| Condition | Containment | Stabilisation | Recovery |
|---|---|---|---|
| No contingency event or load event | 49.5 to 50.5 Hz | | |
| Generation event, load event or network event | 48 to 52 Hz (Queensland and South Australia)<br>48.5 to 52 Hz (New South Wales and Victoria) | 49 to 51 Hz within 2 minutes | 49.5 to 50.5 Hz within 10 minutes |
| Protected event | 47 to 52 Hz | 49.0 to 51.0 Hz within 2 minutes | 49.5 to 50.5 Hz within 10 minutes |
| Multiple contingency event or separation event | 47 to 52 Hz<br>(reasonable endeavours) | 49.0 to 51.0 Hz within 2 minutes<br>(reasonable endeavours) | 49.5 to 50.5 Hz within 10 minutes<br>(reasonable endeavours) |

The mainland *frequency operating standards* during *supply scarcity* apply if:

1. A situation of *supply scarcity* is current.
2. In cases where an island incorporates more than one region then the critical frequency to be adopted is to be the maximum value of the critical frequencies for

these regions ( e.g. for an island comprised of the regions of Victoria and South Australia the critical frequency would be 48.5 Hz)

3. The power system has undergone a contingency event, the frequency has reached the Recovery frequency band and AEMO considers the power system is sufficiently secure to begin load restoration.

4. The estimated amount of load available for under-frequency load shedding within the power system or the island is more than the amount required to ensure that any subsequent frequency excursions would not go below the proposed Containment and Stabilisation bands as a result of a subsequent generation event, load event, network event or a separation event during load restoration.

5. The amount of generation reserve available for frequency regulation is consistent with AEMO's current practice.

### A.1.2 Part B - The frequency operating standards for the mainland

For the purposes of the Rules, the *frequency operating standards*, forming part of the power system security and reliability standards that apply in the mainland are:

(a) except in an island or during supply scarcity, the accumulated time error should not exceed 15 seconds;

(b) except as a result of a contingency event or a load event, system frequency should not exceed the applicable *normal operating frequency excursion band* and should not exceed the applicable *normal operating frequency band* for more than five minutes on any occasion and not for more than 1% of the time over any 30 day period;

(c) as a result of a generation event or a load event, system frequency should not exceed the applicable generation and load change band and should not exceed the applicable *normal operating frequency band* for more than five minutes;

(d) as a result of any network event, system frequency should not exceed the applicable *operational frequency tolerance band* and should not exceed the applicable generation and load change band for more than one minute or exceed the applicable *normal operating frequency band* for more than five minutes;

(e) as a result of any separation event, system frequency should not exceed the applicable island separation band and should not exceed the applicable generation and load change band for more than two minutes or exceed the applicable *normal operating frequency band* for more than ten minutes; and

(f) as a result of any *protected event*, system frequency should not exceed the *extreme frequency excursion tolerance limits* and should not exceed 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*.

(g) following the occurrence of any *non-credible contingency event* or multiple *contingency event* that is not a *protected event*, AEMO should use reasonable 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 exceeding the applicable *normal operating frequency band* for more than ten minutes while there is no *contingency event*.

### A.1.3 Part C - Application of Rules Terms for the mainland

For the purposes of these *frequency operating standards* and Chapters 4, 5 and 10 of the Rules, a term shown in Column 1 of the following table:

i) has the corresponding range shown in Column 3 of the table for an island;

ii) has the corresponding range shown in Column 4 during supply scarcity; and

iii) has the corresponding range shown in Column 2 of the table otherwise.

**Table B.4 NEM mainland frequency operating standards – Rule terms**

| Column 1 | Column 2 | Column 3 | Column 4 |
|---|---|---|---|
| **Term** | **Normal range (Hz)** | **Island range (Hz)** | **Supply scarcity range (Hz)** |
| *normal operating frequency band* | 49.85 to 50.15 | 49.5 to 50.5 | 49.5 to 50.5 |
| *normal operating frequency excursion band* | 49.75 to 50.25 | 49.5 to 50.5 | 49.5 to 50.5 |
| *operational frequency tolerance band* | 49.0 to 51.0 | 49.0 to 51.0 | 48.0 to 52.0 |
| *extreme frequency excursion tolerance limit* | 47.0 to 52.0 | 47.0 to 52.0 | 47.0 to 52.0[151] |

151 Previously this table incorrectly listed the extreme frequency excursion tolerance limit during supply scarcity as 47.0Hz – 55.0Hz. The upper limit has been corrected to 52.0Hz in this FOS.

## A.2 Frequency operating standards for Tasmania

### A.2.1 Part A Summary of the Standards for Tasmania

The Tasmanian *frequency operating standards* set out in Part B of this appendix are summarised in the following tables for convenience. To the extent of any inconsistency between these tables and Part B below, Part B prevails. Table A.2.1 applies to any part of the Tasmanian power system:

**Table A.2.1 Tasmanian frequency operating standards – interconnected system**

| Condition | Containment | Stabilisation | Recovery |
|---|---|---|---|
| Accumulated time error | 15 seconds | | |
| No contingency event or load event | 49.75 to 50.25 Hz<br>49.85 to 50.15 Hz, 99% of the time | 49.85 to 50.15 Hz within 5 minutes | |
| Load event | 48.0 to 52.0 Hz | 49.85 to 50.15 Hz within 10 minutes | |
| Generation event | 48.0 to 52.0 Hz | 49.85 to 50.15 Hz within 10 minutes | |
| Network event | 48.0 to 52.0 Hz | 49.85 to 50.15 Hz within 10 minutes | |
| Separation event | 47 to 55 Hz | 48.0 to 52.0 Hz within 2 minutes | 49.85 to 50.15 Hz within 10 minutes |
| Protected event | 47 to 55 Hz | 48.0 to 52.0 Hz within 2 minutes | 49.85 to 50.15 Hz within 10 minutes |
| Multiple contingency event | 47 to 55 Hz<br>(reasonable endeavours) | 48.0 to 52.0 Hz within 2 minutes<br>(reasonable endeavours) | 49.85 to 50.15 Hz within 10 minutes<br>(reasonable endeavours) |

Table A.2.2 applies to an island within the Tasmanian power system:

**Table A.2.2 Tasmania frequency operating standards – island operation**

| Condition | Containment | Stabilisation | Recovery |
|---|---|---|---|
| No contingency event or load event | 49.0 to 51.0 Hz | | |
| Load and generation event | 48.0 to 52.0 Hz | 49.0 to 51.0 Hz within 10 minutes | |
| Network event | 48.0 to 52.0 Hz | 49.0 to 51.0 Hz within 10 minutes | |
| Separation event | 47 to 55 Hz | 48.0 to 52.0 Hz within 2 minutes | 49.0 to 51.0 Hz within 10 minutes |

| Condition | Containment | Stabilisation | Recovery |
|---|---|---|---|
| Protected event | 47 to 55 Hz | 48.0 to 52.0 Hz within 2 minutes | 49.85 to 50.15 Hz within 10 minutes |
| Multiple contingency event | 47 to 55 Hz<br>(reasonable endeavours) | 48.0 to 52.0 Hz within 2 minutes<br>(reasonable endeavours) | 49.0 to 51.0 Hz within 10 minutes<br>(reasonable endeavours) |

### A.2.2 Part B: the Frequency operating standards for Tasmania

For the purposes of the Rules, the frequency operating standards, forming part of the power system security and reliability standards, that apply in Tasmania are:

(a) except in an island or following a multiple *contingency event,* the accumulated time error should not exceed 15 seconds;

(b) except as a result of a *contingency* or a l*oad* event*,* system frequency should not exceed the applicable *normal operating frequency excursion band* and should not exceed the applicable *normal operating frequency band* for more than five minutes on any occasion and for not more than 1% of the time over any 30 day period;

(c) as a result of a generation event, system frequency should not exceed the applicable generation change band and should not exceed the applicable *normal operating frequency band* for more than 10 minutes;

(d) as a result of a load event, system frequency should not exceed the load change band and should not exceed the applicable *normal operating frequency band* for more than 10 minutes;

(e) as a result of any network event, system frequency should not exceed the applicable *operational frequency tolerance band* and should not exceed the applicable *load change band* for more than one minute or the applicable *normal operating frequency band* for more than 10 minutes;

(f) as a result of any separation event, system frequency should not exceed the applicable island separation band and should not exceed the applicable load change band for more than two minutes or the applicable *normal operating frequency band* for more than 10 minutes;

(g) as a result of any *protected event,* system frequency should not exceed the *extreme frequency excursion tolerance limits* and should not exceed 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*.

(h) following the occurrence of any *non-credible contingency event* or multiple *contingency event* that is not a *protected event*, AEMO should use reasonable endeavours to:

i. maintain system frequency within the applicable *extreme frequency excursion tolerance limits* and

ii. avoid the *system frequency* exceeding the applicable *load change band* for more than two minutes while there is no *contingency event* or exceeding the applicable *normal operating frequency band* for more than 10 minutes while there is no *contingency even*t;

(i) the size of the largest single generator event is limited to 144 MW,[152]which can be implemented for any *generating system* with a capacity that is greater than 144 MW by the automatic tripping of load;

### A.2.3 Part C Application of Rules terms

For the purposes of these *frequency operating standards* and the Rules, a term shown in column 1 of the following table has the corresponding range shown in column 3 of the table for an island and has the corresponding range shown in column 2 of the Table otherwise.

**Tasmanian Frequency Operating Standards – Rule terms**

| Term | Normal range (Hz) | Island range (Hz) |
|---|---|---|
| *normal operating frequency band* | 49.85 to 50.15 | 49.0 to 51.0 |
| *normal operating frequency excursion band* | 49.75 to 50.25 | 49.0 to 51.0 |
| *operational frequency tolerance band* | 48.0 to 52.0 | 48.0 to 52.0 |
| *extreme frequency excursion tolerance limit* | 47.0 to 55.0 | 47.0 to 55.0 |

152 AEMO may in accordance with clause 4.8.9 direct a Generator to exceed the 144 MW contingency limit if AEMO reasonably believes this would be necessary in order to maintain a reliable operating state.

## A.3 Part D - Definitions for the frequency operating standards

| Term | Definition |
|---|---|
| *accumulated time error* | means, in respect of a measurement of *system frequency* that AEMO uses for controlling *system frequency*, the integral over time of the difference between 20 milliseconds and the inverse of that *system frequency*, starting from a time *published* by *AEMO*. |
| *available capacity* | has the meaning given to it in the Rules. |
| *connection point* | has the meaning given to it in the Rules. |
| *contingency event* | has the meaning given to it in the Rules. |
| *credible contingency event* | has the meaning given to it in the Rules. |
| *extreme frequency excursion tolerance limits* | has the meaning given to it in the Rules. |
| *frequency operating standards* | has the meaning given to it in the Rules and are the standards set out in Part B of this document. |
| Generating system | has the meaning given to it in the Rules. |
| *generating unit* | has the meaning given to it in the Rules. |
| *generation* | has the meaning given to it in the Rules. |
| Generation change band | for the mainland - means the frequency range of 49.0 to 51.0 Hz in respect of an island and the frequency range of 49.5 to 50.5 Hz otherwise.<br><br>for Tasmania - means the frequency range of 48.0 to 52.0 Hz in respect of an island and otherwise. |
| *generation event* | means:<br>1. a *synchronisation* of a *generating unit* of more than 50 MW, or<br>2. an event that results in the sudden, unexpected and significant increase or decrease in the *generation* of one or more *generating systems,* totalling more than 50MW in aggregate, within a period of 30 seconds or less, or<br>3. a *credible contingency event*, not arising from a load event, a *network event*, a *separation event* or a part of a *multiple contingency event*." |

| Term | Definition |
|---|---|
| | |
| Interconnector | A *transmission line* or group of *transmission lines* that connects the *transmission networks* in adjacent regions. |
| *island* | means a part of the *power system* that includes *generation*, *networks* and *load*, for which all of its alternating current network connections with other parts of the *power system* have been disconnected, provided that the part:<br>(a) does not include more than half of the combined *generation* of each of two *regions* (determined by available capacity before disconnection); and<br>(b) contains at least one whole inertia sub-network. |
| *island separation band* | for the mainland - means:<br>(a) in respect of a part of the power system that is not an island, the operational frequency tolerance band;<br>(b) in respect of an island that includes a part of the power system to which no notice under paragraph (c) applies, the operational frequency tolerance band; and<br>(c) otherwise in respect of an island, the frequency band determined by the most restrictive of the high limits and low limits of frequency ranges outside the operational frequency tolerance band notified by Jurisdictional Coordinators to AEMO with adequate notice to apply to a nominated part of the island within their respective jurisdictions.<br><br>for Tasmania - means the *extreme frequency excursion tolerance limits* |
| *Jurisdictional Coordinator* | has the meaning given to it in the Rules. |
| *load* | has the meaning given to it in the Rules. |
| Load change band | for the mainland - means the frequency range of 49.0 to 51.0 Hz in respect of an island and the frequency range of 49.5 to 50.5 Hz otherwise.<br><br>for Tasmania - means the frequency range of 48.0 to 52.0 Hz in respect of an island and otherwise. |
| *load event* | for the mainland - means an identifiable connection or disconnection of more than 50 MW of customer load (whether at a *connection point* or otherwise), not arising from a *network event, a generation event, a separation event* or a part of a *multiple contingency event*.<br><br>for Tasmania - means an either an identifiable increase or decrease of more than 20 MW of customer load (whether at a *connection point* or otherwise), or a rapid change of flow by a *high voltage* direct current interconnector to or from 0 MW for the purpose of |

| Term | Definition |
|---|---|
| | starting, stopping or reversing its power flow, not arising from a network event, a *generation event, a separation event* or a part of a *multiple contingency event* |
| Market network service provider | has the meaning given to it in the Rules. |
| *multiple contingency event* | means either a *contingency event* other than a *credible contingency event,* a sequence of *credible contingency events* within a period of 5 minutes, or a further *separation event in an island.* |
| National grid | has the meaning given to it in the Rules. |
| *AEMO* | has the meaning given to it in the Rules. |
| *network* | has the meaning given to it in the Rules. |
| *network event* | means a *credible contingency event* other than a *generation event*, a separation event or a part of a *multiple contingency event.* |
| *normal operating frequency band* | has the meaning given to it in the Rules. |
| *normal operating frequency excursion band* | has the meaning given to it in the Rules. |
| *operational frequency tolerance band* | has the meaning given to it in the Rules. |
| *power system* | has the meaning given to it in the Rules. |
| *power system security and reliability standards* | has the meaning given to it in the Rules. |
| *publish* | has the meaning given to it in the Rules. |
| *region* | has the meaning given to it in the Rules. |
| Rules | The Rules means National Electricity Rules |
| *separation event* | means a *credible contingency* event in relation to a *transmission element* that forms an *island.* |
| *supply scarcity* | means the condition where *load* has been disconnected either manually or automatically, other than in accordance with dispatch instructions or service provision, and not yet restored to supply. |
| Synchronisation | The act of synchronising a *generating unit* or a scheduled network service to the *power system* |
| *synchronisation* | has the meaning given to it in the Rules. |
| *system frequency* | means the frequency of a part of the *power system,* including the *frequency* of an *island.* |

| Term | Definition |
| --- | --- |
| Technical envelope | has the meaning given to it in the Rules. |
| *transmission element* | has the meaning given to it in the Rules. |

# B Summary of stakeholder submissions

## B.1 Summary of the stakeholder submissions to the issues paper

| Stakeholder | Issue/Comment | Reliability Panel Response |
|---|---|---|
| **FOS for Protected Events** | | |
| ENA | ENA supports the inclusion of protected events in the FOS and notes that the interim FOS is useful. | Noted. See section 4.2. |
| ENGIE | ENGIE suggest that the FOS for each protected event be individually specified. | Noted. See section 4.2. |
| Meridian Energy | Meridian Energy considers that the Panel should balance cost burdens against the likelihood and significant of protected events. | Noted. See section 4.2. |
| TasNetworks | TasNetworks is supportive of the interim FOS for protected events, subject to more rigorous analysis being undertaken. | Noted. See section 4.2 |
| ERM Power | ERM believe that the FOS for a protected event should be set equivalent to a separation event base on the expected impact of the event. | Noted. See section 4.2 |
| AEMO | AEMO consider that the interim FOS for protected events are workable and has not identified any reason to vary them. | Noted. See section 4.2 |
| Origin Energy | Origin note that where a protected event is declared, a combination of market mechanisms and EFCS should be used to manage the impact of that event. | Noted. See section 4.2 |
| Energy Australia | Energy Australia consider that the FOS for protected events should be set as close to the current non-credible contingency standard as possible to minimise cost of compliance.<br>Energy Australia recognise that the consistency benefits of a blanket FOS for protected events may outweigh the benefits of customised settings for each protected event due to the complexity of bespoke solutions. | Noted. See section 4.2 |
| Department of the Premier and Cabinet, South Australia | The South Australian government support the interim FOS for protected events as a starting point, however note that this standard will not be adequate for South Australia in the absence of additional security obligations. The South Australian government request that the Panel | Noted. See section 4.2 |

| Stakeholder | Issue/Comment | Reliability Panel Response |
|---|---|---|
| | consider including a limit on the rate of change of frequency as an element of the FOS for protected events on a case by case basis | |
| **Multiple contingency events in the FOS** | | |
| ENA | ENA propose that a “reasonable endeavours” requirement be included in the FOS in relation to management of the power system following multiple contingency events. | Noted. See section 4.3 |
| SACOSS | SACOSS believe that it is important for the FOS to retain some requirement in relation to power system operation following multiple contingency events. | Noted. See section 4.3 |
| ENGIE | ENGIE support the removal from the FOS of the requirement for managing the power system following multiple contingency events. | Noted. See section 4.3 |
| TasNetworks | TasNetworks accepts the practical limitations of eth current requirement for managing the power system frequency following multiple contingency events. They consider that a ‘reasonable’ or ‘best endeavours’ approach would be a worthwhile option to explore. | Noted. See section 4.3 |
| ERM Power | The FOS for multiple contingency events should define specific events for which the extreme frequency tolerance excursion limit should be maintained, such as the simultaneous loss of all generating units at a single power station. | Noted. See section 4.3 |
| Energy Australia | Energy Australia support the revision of the multiple contingency requirement as a general obligation, alternatively this requirement could be expressed as a targeted obligation to prevent system collapse for specific events. | Noted. See section 4.3 |
| Department of the Premier and Cabinet, South Australia | The South Australian government while there is a case for revision of the requirement in the FOS for multiple contingency events, however there is “"little reason to consider a region-specific element of the FOS related to multiple contingency events.” | Noted. See section 4.3 |
| **Definitions related to island operation** | | |
| ENA | ENA considers there are similarities between the goals for power system | Noted. See section 4.5. |

| Stakeholder | Issue/Comment | Reliability Panel Response |
|---|---|---|
| | management for protected events, inertia sub-networks and island operation under the FOS.<br>ENA does not see any need for alignment of the requirements for island operation under the FOS and sub-networks for procurement of system restart ancillary services. | |
| SACOSS | SACOSS support clarification of the characteristics of an island for the FOS. | Noted. See section 4.5. |
| ENGIE | ENGIE suggest that the FOS contain a set of principles that can be applied by AEMO to determine which section in the NEM may be treated as potential islands for the purpose of the FOS. | Noted. See section 4.5. |
| Meridian Energy | Meridian Energy support a simple and sensible measure to determine the characteristics of a viable island for the maintenance of the FOS. | Noted. See section 4.5 |
| TasNetworks | TasNetworks support further guidance on the characteristics of a viable island for the FOS and lists a number of specific concerns related to this issue. | These concerns are addressed in detail in section 4.5. |
| ERM Power | ERM supports the suggested revision of the definition of an island for the FOS. The definition should be linked to the goal of satisfactory operation of the island. | Noted. See section 4.5 |
| AEMO | AEMO believe that the definition of an island for the FOS should be consistent with the requirements for an inertia sub-network. | Noted. See section 4.5 |
| Origin Energy | Origin supports consistency of policy in general, including that the subnetworks for the inertia and SRAS are aligned with the regions for island operation under the FOS. The goal of an island is to maintain safe and secure operation to ensure plant operating within their performance standards are not damaged or forced to trip off. | Noted. See section 4.5 |
| PIAC | PIAC recommend that the Panel consider cost benefit trade-offs as well as technical considerations when determining the characteristics of an island for the FOS. | Noted. See section 4.5 |
| Department of the Premier and Cabinet, South | The South Australian government agree with the proposed revision to the definition related to island operation under the FOS. | Noted. See section 4.5 |

| Stakeholder | Issue/Comment | Reliability Panel Response |
|---|---|---|
| Australia | | |
| **Definition of a generation event** | | |
| ENA | ENA support the revision of the definition of the term “generation event” so it is more operationally realistic. Such a revision should account for the sudden and unexpected increase or decrease of generation output. | Noted. See section 4.4. |
| ENGIE | ENGIE support the standardisation of terminology definitions amongst the NEM regions as much as is practicable. | The draft FOS for stage one includes a single set of definitions that applies to both Tasmania and the mainland NEM. |
| Meridian Energy | Meridian supports the general standardisation of the definition of terms in the FOS.<br>Meridian also support the revision of the definition of generation event to reflect actual changes in generation performance in light of newer technologies such as inverter based generation. | Noted. See section 4.4. |
| TasNetworks | In terms of the definition of generation event and the issue of rapid and unexpected variation of generation output, TasNetworks suggest that the Panel consider whether these events should be treated as part of normal operation or as contingency events. | Noted. See section 4.4. this issue will be considered further during stage two of the review as discussed in section 5.1 and 5.2. |
| ERM Power | ERM support the standardisation of the definition in the FOS, where appropriate.<br>ERM support also the revision of the definition of a generation event, suggesting the following wording:<br>“the unforecast and sudden decrease or increase exceeding 50MW of generator output from a generating unit” | Noted. See section 4.4. |
| AEMO | AEMO support the revision of the definition of generation event definition, noting that the revised definition should:<br>• cover the sudden unexpected variation of generation resulting from a common event<br>• be linked to the declaration of a credible contingency, to be determined by AEMO. | Noted. See section 4.4. |
| Department of the Premier and | The South Australian government agree with the proposal to revise the definition of | Noted. See section 4.4. |

| Stakeholder | Issue/Comment | Reliability Panel Response |
|---|---|---|
| Cabinet, South Australia | a generation event, adding that the consideration of a single point of failure impacting a network element solely providing connection to generation element should also be considered. | |
| **Consideration of accumulated time error** | | |
| ENA | ENA suggest that the requirement in the FOS to limit accumulated time error may be reduced by a guideline in order to maintain the reporting of time error as a measure of system performance. | Noted. See section 4.6, |
| SACOSS | SACOSS believe that the FOS should no longer require AEMO to limit accumulated time error. | Noted. See section 4.6, |
| ENGIE | ENGIE support the removal of accumulated time error from the FOS as its relevance has diminished. | Noted. See section 4.6, |
| Meridian Energy | Meridian Energy support the relaxation or removal of the limit on accumulated time error in the FOS. They note that accumulated time error is of little value in today's digital world where all consumer have access to accurate time keeping devices. | Noted. See section 4.6, |
| TasNetworks | TasNetworks notes that the reduced dependence on time error likely justifies the removal of a formal accumulated time error standard.<br>TasNetworks notes there is continued value in the reporting of accumulated time error as a measure or power system performance. | Noted. See section 4.6, |
| ERM Power | ERM support the removal of accumulated time error from the FOS, pending further analysis by the Panel that confirms the benefits of this change. | Noted. See section 4.6, |
| AEMO | AEMO is not aware of any consumer complaints in relation to time error and accurate time keeping, including following the islanding events and manual resetting of time error.<br>AEMO offers to assist the Panel to investigate the costs and benefits of time error correction with a view to discontinuing or relaxing the requirement to limit accumulated time error. | Noted. See section 4.6, |
| PIAC | PIAC recognise that synchronous clocks | Noted. See section 4.6, |

| Stakeholder | Issue/Comment | Reliability Panel Response |
|---|---|---|
| | have become less common, therefore the importance of obligations relating to accumulated time error have diminished. | |
| **Stage two issues** | | |
| ENA | ENA propose that the panel consider the inclusion in the FOS of a limit on rate of change of frequency. | Noted for consideration during stage two. See section 5.4. |
| ENGIE | ENGIE note that stage two could consider whether the FOS should contain a standard for rate of change of frequency. | Noted for consideration during stage two. See section 5.4. |
| Meridian Energy | Meridian Energy request that the Panel consider in depth the potential impacts of the introduction of significant quantities of distributed storage at both a utility and household scale and how the FOS can interact with such devices to enhance system security. | Noted for consideration during stage two. See chapter 5 of the draft determination. |
| TasNetworks | TasNetworks raised a number of issues for further consideration during stage two of the review including:<br>• Consider extending the 144MW limit on a generation event to cover network events.<br>• Consider including a ROCOF limit in the FOS.<br>• Consider the impact of demand response mechanism and ancillary service unbundling rule change relating to the performance of fast FCAS delivered through switching controllers.<br>• recommended that load and generation events in the TFOS be separated. | Noted for consideration during stage two.<br>• See section 5.2.2.<br>• See section 5.4.<br>• to be address in the *Frequency control frameworks review*.<br>• see section 5.2.1. |
| ERM Power | ERM suggest that a more refined breakup of the probabilistic distribution of the power system frequency during normal operation be considered. ERM suggest that the frequency distribution for normal operation be specified by as many as 5 frequency bands with corresponding percentage of time requirements. | Noted for consideration during stage two. See section 5.1. |
| Origin Energy | Origin support a review to update the Value of customer reliability (VCR)<br>Origin request that the Panel consider how new FFR services may impact the FOS. | Noted. VCR is estimated by AEMO.<br>Noted, see section 5.1.2. |
| PIAC | PIAC note that it is essential that the Panel bear in mind the cost implications related to measures intended to increase system | Noted. |

| Stakeholder | Issue/Comment | Reliability Panel Response |
|---|---|---|
| | security. | |
| Energy Australia | Energy Australia note the following points for consideration during stage two:<br>• The NOFB and the contingency bands are most suitable for determination by a cost benefit assessment.<br>• The Panel should examine what "good frequency control" within the NEM is, including assessing the benefits of a tighter frequency distribution during normal operation.<br>• The Panel should identify drivers of change that may impact frequency control such as new generation technologies and behind the meter response. | Noted for consideration during stage two.<br>• see section 5.1<br>• see section 5.1.<br>• see chapter 5 of the draft determination. |
| Department of the Premier and Cabinet, South Australia | The South Australian government request that the Panel consider the inclusion of a limit on rate of change of frequency in the FOS. | Noted for consideration during stage two. See section 5.4. |

## B.2 Summary of the stakeholder submissions to the draft determination

| Stakeholder | Issue/Comment | Reliability Panel Response |
|---|---|---|
| **FOS for Protected Events** | | |
| AEMO | AEMO supports the proposed revisions to the standard to include protected events. | Noted.<br>See section 4.2.2. |
| ENA | ENA support the standard for protected events set out in the Draft FOS. | Noted.<br>See section 4.2.2. |
| Energy Australia | Energy Australia support the standard for protected events set out in the Draft FOS. | Noted.<br>See section 4.2.2. |
| Meridian Energy | Meridian agrees that that following a protected event the frequency should remain within the emergency frequency excursion tolerance limits. | Noted.<br>See section 4.2.2. |
| Origin Energy | Origin support the introduction of the protected event category to the FOS and the application of frequency excursion tolerance limits as the standard for these events. | Noted.<br>See section 4.2.2. |

| Stakeholder | Issue/Comment | Reliability Panel Response |
|---|---|---|
| **Multiple contingency events in the FOS** | | |
| AEMO | AEMO considers that the proposed FOS provision in relation to multiple contingency events is a remnant from the previous regime, and should be removed or amended to:<br>• Clarify how AEMO is intended to apply the requirement<br>• Be consistent with the NER | Noted.<br>See section 4.2.2. |
| ENA | ENA support inclusion of the reasonable endeavours – multiple contingency requirement set out in the draft FOS | Noted.<br>See section 4.2.2. |
| Meridian Energy | Meridian agrees with the reasonable endeavours – multiple contingency requirement set out in the draft FOS | Noted.<br>See section 4.3.2. |
| Origin Energy | Origin supports maintaining a clear "reasonable endeavours" obligation on AEMO to manage frequency within the FOS for multiple contingency events. | Noted.<br>See section 4.3.2. |
| **Definitions related to island operation** | | |
| AEMO | AEMO supports the proposed revisions to the standard relating to how island operation is defined. | Noted.<br>See section 4.5.2. |
| ENA | ENA support the proposed definition of an 'island' in applying the FOS for island operation. | Noted.<br>See section 4.5.2. |
| Origin Energy | Origin is comfortable with the definition of an electrical island aligning with the inertia subnetworks as set out in the draft FOS. | Noted.<br>See section 4.5.2. |
| **Definition of a generation event** | | |
| AEMO | AEMO supports the proposed revisions to the standard relating to the definition of generation event. | Noted.<br>See section 4.4.2. |
| CS Energy | CS Energy made the case that the definition of generation event should not be changed to include the variation of generation output. | Noted.<br>See section 4.4.2. |
| ENA | ENA supports the proposed revisions to the standard relating to the definition of generation event. | Noted.<br>See section 4.4.2. |
| Energy Australia | ENA support further examination of the proposed definition of generation event | Noted. |

| Stakeholder | Issue/Comment | Reliability Panel Response |
|---|---|---|
| | through stage two of the review. This should include additional detail on the increased likelihood of a generation event occurring under the revised definition and the implications for the market. | See section 4.4.2. |
| Origin Energy | The addition of a generation event to include a sudden increase or decrease in generation of 50MW or more is welcome. Allowing AEMO to utilise both Regulation and Contingency FCAS should enable lowest priced outcomes to be achieved. | See section 4.4.2. |
| **Consideration of accumulated time error** | | |
| AEMO | AEMO supports the proposed revisions to the standard related to time error correction, and considers that the phased approach that first relaxes the accumulated time error limit is a reasonable approach. | Noted.<br>See section 4.6.2. |
| CS Energy | CS Energy expressed their view that the limit on accumulated time error should not be changed as it acts as a "canary in the coal mine" to identify poor frequency performance. | Noted.<br>See section 4.6.2. |
| ENA | ENA support the increase of the limit on accumulated time error for the mainland to 15 seconds, in line with the limit for Tasmania. | Noted.<br>See section 4.6.2. |
| Origin Energy | Origin supports relaxing the accumulated time error from 5 seconds to 15 seconds to determine if there are any unintended consequences that may affect NEM participants. | Noted.<br>See section 4.6.2. |
| **Stage two issues** | | |
| ENA | ENA request further discussion on the following issues through stage two of the review:<br>• whether a general limit should be placed on the rate of change of frequency in the FOS<br>• benefits in keeping a performance measure on accumulated time error. | Noted. See section 3.2.2. |
| Energy Australia | Energy Australia indicated the following:<br>• Support for the exploration of the removal of the limit on accumulated time error, along with expressing the importance of widespread community engagement on this issue to avoid | Noted. See section 3.2.2. |

| Stakeholder | Issue/Comment | Reliability Panel Response |
|---|---|---|
| | serious unintended consequences.<br>• Support for the reassessment of the 99% requirement to maintain the power system frequency within the NOFB and corresponding 1 % allowance for exceeding the NOFB but staying within the normal operating frequency excursion band.<br>Such a consideration should include the identification of a preferred frequency distribution for normal operation along with how such a distribution could be achieved and the costs of achieving it.<br>• To inform the assessment of the undertake an international comparison of best practise frequency control both in terms of the respective frequency bands and the mechanisms that exist to maintain good frequency control. | |
| Meridian Energy | Meridian recommends that, where possible, the findings from the AER's investigation into the system black event in South Australia in September 2016 be reviewed and incorporated into any final determination.<br>In addition Meridian also note the role of the AEMC's Frequency Control Market Frameworks Review (specifically governor response) and the implications of this review to the extent they relate to the FOS. | Noted. See section 3.2.2. |
| Origin Energy | Removal of the limit on accumulated time error during Stage 2 of the FOS review is premature. A longer evaluation period, (e.g. until the next FOS review) would allow for the effects of the time error change to be evaluated.<br>When setting the boundaries of the frequency bands in the FOS the Panel should consider:<br>• the availability of regulation and contingency FCAS and the interaction of this availability the energy market<br>• the impact of the Frequency control frameworks review and any associated reforms that impact generator governor settings<br>• the impact of increasing frequency fluctuations in the NEM during normal operation and the increased wear and tear costs borne by generators<br>• the impact of fast frequency response | Noted. See section 3.2.2. |

| Stakeholder | Issue/Comment | Reliability Panel Response |
|---|---|---|
| | services<br>• a general discussion on the definition of credible contingencies. | |

# C Terms of Reference

**Revised – 12 September 2017**

**Introduction**

Under section 38 of the National Electricity Law (NEL) and clause 8.8.3(c) of the National Electricity Rules (NER), the Australian Energy Market Commission (AEMC) requests that the Reliability Panel (the Panel) undertake a review of the frequency operating standards that apply in the National Electricity Market (NEM). This review is related to and is intended to complement the ongoing work program that the AEMC is undertaking to enable the maintenance of power system security in the NEM.

**Background**

**The frequency operating standard*s* (FOS):** NER clause 8.8.1(a)(2) requires the Reliability Panel to review and, on the advice of AEMO, determine the power system security standards. These standards may include various matters but at present include standards for the range of allowable frequency of the power system under different conditions, including normal operation and following contingencies. These standards are set out in the FOS.

The FOS set out the frequency standards to which AEMO operates the power system. This includes defined frequency bands and timeframes in which the system frequency must be restored to these bands following different events, such as the failure of a transmission line or separation of a region from the rest of the NEM. These requirements then inform how AEMO operates the power system, including through applying constraints to the dispatch of generation or procuring ancillary services.

The FOS currently consists of two separate standards: one for the mainland NEM, and one for Tasmania. This reflects the different physical and market characteristics of the Tasmanian region as opposed to the mainland NEM. The frequency operating standard for Tasmania was last reviewed and determined by the Reliability Panel on 18 December 2008. The frequency operating standard for the mainland was last reviewed and determined by the Reliability Panel on 16 April 2009.

**The Panel's role and responsibility in relation to the FOS**: Clause 8.8.1(a)(2) of the National Electricity Rules (NER or the rules) requires the Reliability Panel to: "review and, on the advice of AEMO, determine the power system security standards". The reliability panel is required to determine the FOS as a subset of the power system security standards.

**The *Emergency frequency control scheme rule* change:** On 30 March 2017 the AEMC published the final rule and accompanying final determination for the Emergency Frequency Control Schemes rule change (ERC0212).

A number of issues relevant to the Panel's review of the FOS were identified or addressed in the final rule determination of the emergency frequency control schemes rule change. These include:

- A review of the appropriateness of the requirements in the FOS that relate to multiple contingency events.[153] Currently, the FOS defines the standard to which AEMO manages the power system following any multiple contingency event. AEMO has argued that this is impractical, as it is not possible to maintain the FOS for all multiple contingencies.
- How the new event classification for "protected events" can best be incorporated into the FOS. The Emergency frequency control schemes rule change introduced a new category of contingency event, the "protected event". AEMO is now required to maintain the frequency of the power system within certain bands for these events. These requirements will be defined in the FOS.

The final rule for the Emergency frequency control schemes rule change includes an interim frequency standard that shall apply for any protected event(s) that may be declared prior to this review of the FOS being completed. Accordingly, following the review, the revised FOS for protected events may replace this interim requirement.

**Scope of the review**

The Panel is requested to undertake a review of the NEM mainland and the Tasmanian frequency operating standards.

In undertaking this review, the Panel should give consideration to key system security issues currently being addressed by the AEMC and AEMO. This should include, but is not limited to, the consequences of the changing NEM generation fleet, including the impacts of decreased system inertia and associated rates of change of frequency following a contingency event.

Relatedly, the Panel should give consideration to the findings and recommendations of the following work programs:

- AEMC's system security market framework review;
- AEMO's Future Power System Security review;
- AEMC Frequency Control Frameworks Review
- Rule change requests currently on foot that are relevant to the issues that will need to be considered in the review, including the *Managing the rate of change of power system frequency* rule change.

Given these key issues and the ongoing work programs, in undertaking this review, the Panel should give consideration to:

- Whether the terminology, standards and settings and definitions in the FOS remain appropriate.

153 Part B (f) of the Frequency Operating Standard for the mainland.
Part B (g) of the Frequency Operating Standard for Tasmania.

- What amendments to the FOS may be necessary in light of the AEMC's final determination of the Emergency frequency control schemes rule change published on 30 March 2017
- Whether further guidance can be provided regarding the definition of what part of the power system the FOS is to be applied following separation from the rest of the NEM. Specifically, whether the FOS should refer to a separated region, or some smaller sub-section of a region, for maintenance of frequency following a separation event.
- Other issues related to the FOS as determined by the Panel.

The Panel's review of the FOS must consider and determine FOS to apply to both Tasmania and the mainland regions of the NEM. This must include consideration of the different physical and market characteristics relating to the power system. Given that Tasmania and the mainland are electrically separated in terms of frequency, the review shall consider the different physical and market characteristics of each of these regions in determining the settings for the FOS.

**Timing and Consultation Process**

In conducting this review the Panel may determine its own approach, including the staging of issues to be addressed, but must carry out the review to develop the FOS in accordance with the following consultation processes:

- Give notice to all registered participants of commencement of this review.
- Publish an issues paper for consultation with stakeholders following the notification of the commencement of the review and invite submissions for a period of at least three weeks. This paper should outline the key issues and questions the Panel will consider when determining the FOS.
- Publish a draft report or reports and invite submissions for a period of at least four weeks.
- At the time of publishing the draft report(s), notify stakeholders that they may request a public meeting on the draft report(s) within five business days of the draft report(s) being published.
- If stakeholders have requested a public meeting, notify stakeholders that a public meeting will be held. At least two weeks' notice of the public meeting must be given.
- Publish a final report or reports and submit this report(s) to the AEMC no later than six weeks after the period for consultation on the draft report(s) has closed.

The Panel may decide on its own timing for delivery of the review, provided the review is completed by 31 July 2018.

# D Past Reviews of the FOS

## D.1 Reliability Panel Review: Application of FOS During Periods of Supply Scarcity 2009

Following the blackout that occurred in Victoria on 16 January 2016, related to severe bushfire activity, the reliability panel revised the FOS for the mainland NEM to support a more rapid restoration of supply following a major power system incident. An additional table was added to the FOS for the Mainland NEM to apply during periods of supply scarcity, following automatic load shedding.

This change was made in an effort to shorten the restoration time for the power system following major incidents through the increased utilisation of available generation capacity. The FOS during period of supply scarcity is wider than that for normal interconnected system conditions, which reduces the amount of FCAS that are required to manage the power system frequency, this in turn slightly increase the generation capacity available to supply load, and thus reduces the restoration time.

## D.2 Reliability Panel Review: Tasmanian FOS Review 2008

The FOS that applies for Tasmania was last reviewed and determined by the reliability panel on 18 Dec 2008.[154] At that time the Panel considered revisions to the Tasmanian FOS that would more closely align the FOS for Tasmania with that for the mainland NEM. A primary goal for the review was to set the standard to support a more diverse range of electricity generating technologies to increase the security and reliability of energy supplies in Tasmanian and facilitate competition.

The 2008 review made the following changes to the FOS for Tasmania:

- increasing lower limit of the extreme frequency excursion tolerance limit from 46 Hz to 47 Hz
- increasing the lower limit of the load, generator and network event band to 48 Hz, thus requiring the under frequency load shedding scheme (UFLSS) to operate between 48 and 47 Hz
- aligning the upper limit of the operational tolerance frequency band for load, generator and network events to 52 Hz, thus allowing efficient thermal generating units to meet the minimum access standards
- aligning the recovery times for load, generator and network events to 10 minutes
- reducing the over frequency limit for extreme events under island conditions from 60 Hz to 55 Hz
- a limit of 144MW was applied to the size of a contingency event that must be managed in accordance with the FOS.

154 In 2006, the Panel conducted a review of the FOS that applies to Tasmania following the inclusion of Tasmania in the NEM. This review confirmed that the previous FOS for Tasmania would continue to apply until such time as the Panel completed a more thorough review. See: AEMC Reliability Panel, 2006, [154154] Tasmanian Reliability and Frequency Standards – determination.

## D.3 Reliability Panel Review: FOS (Mainland NEM)

The FOS for the mainland NEM was thoroughly reviewed and determined by the reliability Panel on 30 September 2001. This review was undertaken to address the growth of the NEM, including the addition of the Queensland region into the interconnected NEM.

The 2001 review made the following changes to the FOS for the mainland NEM:

- relaxation of the normal frequency band from 49.9 - 50.1 Hz to 49.85 - 50.15 Hz
- creation of a probabilistic tolerance for the normal band of 99 per cent of the time
- amalgamation of the standard for load disturbances with the standard for single generator disturbances
- increase of the maximum time to stabilise the power system frequency following multiple contingencies
- establishment of a uniform base standard when a contingency event may result in separation of parts of the network and provide for a Jurisdictional Co-ordinator to advise NEMMCO of a relaxation of this requirement
- tighten the standards that apply to island operation in the absence of disturbing events
- amend the allowable time error from 3 seconds to 5 seconds.

The relaxation of the normal operating frequency band and the addition of the probabilistic tolerance of 99 per cent were intended to reduce the quantity of ancillary services required to be procured by the market operator. This change also allowed the market operator to, within limits, vary the amount of ancillary service in response to market price.