RELIABILITY PANEL AEMC

DETERMINATION

Reliability Panel AEMC

**FINAL REPORT**

# REVIEW OF THE FREQUENCY OPERATING STANDARD - STAGE TWO

18 APRIL 2019

## INQUIRIES

Reliability Panel
c/- Australian Energy Market Commission
PO Box A2449
Sydney South NSW 1235

E aemc@aemc.gov.au
T (02) 8296 7800
F (02) 8296 7899

Reference: REL0065

## CITATION

Reliability Panel, Review of the Frequency Operating Standard — Stage two, Final Determination, 18 April 2019, Sydney

## ABOUT THE RELIABILITY PANEL

The Panel is a specialist body established by the Australian Energy Market Commission (AEMC) in accordance with section 38 of the National Electricity Law and the National Electricity Rules. The Panel 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.

## RELIABILITY PANEL MEMBERS

Brian Spalding, Chairman and AEMC Commissioner
Trevor Armstrong, Chief Operating Officer, Ausgrid
Mark Collette, Executive Energy, EnergyAustralia
Stephen Clark, Technical and Economic Lead – Project Marinus, TasNetworks
Kathy Danaher, Chief Financial Officer and Executive Director, Sun Metals
Gavin Dufty, Manager Policy and Research, St Vincent de Paul Society, Victoria
Chris Murphy, Strategic Advisor—Meridian Energy; General Manager — Energy Market Interfaces, Telstra
Damien Sanford, Chief Operations Officer, AEMO
John Titchen, Managing Director, Goldwind Australia
Richard Wrightson, Executive General Manager Wholesale Markets, AGL Energy

# EXECUTIVE SUMMARY

The Reliability Panel (Panel) has made this determination for stage two 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).

The Reliability Panel has determined a FOS which largely maintains the existing settings in the FOS in relation to the requirements for frequency performance in the NEM. The Panel considers that the FOS adequately specifies the requirements for frequency performance in the NEM at the current time.

The Panel notes that there is an active frequency control work program under way by the AEMC and AEMO to investigate the immediate and future needs of the power system in relation to frequency control. In particular the Panel notes the findings from AEMO's investigation into the separation event that occurred in the NEM on 25 August 2018. In AEMO's operating incident report for this event, it noted that the power system response to the separation of the Queensland region from the rest of the National electricity system, showed a decrease in resilience of the power system frequency to larger non-credible contingency events. As a result, AEMO is currently working with the AEMC, AER and market participants to implement measures to increase the provision of primary frequency control from capable generation to arrest the decline in system resilience to larger contingency events and maintain frequency closer to 50 Hz.

The Panel is aware that it may need to revisit the FOS again in the short to medium term to accommodate any recommended changes to the frequency control philosophy that are necessary to specify the power system security requirements as the NEM evolves.

**What is the FOS?**

The FOS includes defined frequency bands and time frames 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. This review has been undertaken in two stages to accommodate interactions with related work programs, particularly the AEMC's *Frequency control frameworks review*.

This final determination for stage two of the FOS review resolves a number of remaining issues identified in stage one of the review, except for the following issues that are being considered by the AEMC as part of its ongoing frequency control work program following on from the *Frequency control frameworks review*:

- Reviewing the requirements in the FOS for frequency performance during normal operation
- Consideration of the inclusion in the FOS of a standard for the rate of change of frequency in the power system

This determination sets out the Panel's considerations in relation to the FOS for stage two of the review (the FOS).

**The FOS**

The Panel has made a FOS for Tasmania and for the mainland, which responds to a number of issues that were identified through stage one of this review. The revised FOS will take effect on 1 January 2020 to allow for affected parties to make arrangements to adjust to the revised requirements. The revised FOS differs from the current FOS in the following ways:

- The limit on the size of the largest generation event in the Tasmanian power system

  The FOS includes revisions that clarify the scope of the existing 144MW limit in relation to the operation of the Tasmanian power system. This limit was included in the FOS by the Panel following the 2008 review of the FOS for Tasmania. In the context of the operational limitations of the Tasmanian power system, it limits the quantity and cost of contingency FCAS required to manage larger contingency events in the Tasmanian system. The particular changes in the FOS in relation to this issue include:

  - The definition of a generation event includes the disconnection of generation as the result of a credible contingency in relation to a dedicated connection asset providing connection of one or more generating systems to the shared transmission network.
  - Clarification that the limit for the largest generation event in the Tasmanian system applies for disconnection of generation based on an initially intact network, in the absence of network outages. This means that the limit does not apply in the event of planned network outages. AEMO has established operational procedures to manage the need for contingency FCAS at these times.
- Improvements to the structure and consistency of the FOS

  The FOS has been restructured and consolidated to avoid duplication and improve the clarity of the obligations that it places on AEMO to manage the power system frequency.

This determination also includes a summary of the Panel's considerations in relation to:

- the settings in the FOS that relate to contingency events
- the limit in the FOS on accumulated time error.

On the advice of AEMO, the Panel has maintained the existing settings in the FOS in relation to these issues, noting that immediate priorities are:

- the joint AEMC-AEMO frequency control work plan published as part of the final report for the Frequency control frameworks review.
- the implementation of recommendations stemming from AEMO investigation of the separation event that occurred in the NEM on 25 August 2018, including measures to increase the provision of primary frequency control in the NEM

The Panel notes that there is scope for further refinement of the FOS in subsequent reviews of the FOS.

# CONTENTS



## APPENDICES



## TABLES

## FIGURES

# 1 INTRODUCTION

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

This review has been undertaken over two stages. The Panel published a final determination for stage one of the review on 17 November 2017. The Panel's findings for stage two of the review 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 time frames 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 time frames that are referred to by the access standards that apply to generator and network equipment in the NEM. In combination with the FOS, these access standards align the power system frequency managed by AEMO with the capability of NEM power system equipment, including generating systems and network equipment.

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 26 July 2018, the AEMC published a revised terms of reference for the stage two of the review of the FOS. The revised Terms of Reference sets the high level scope for the Panel to consider, including:

- whether the terminology, standards and settings and definitions in the FOS remain appropriate, including:

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

  - the settings of the frequency bands and time requirements for maintenance and restoration of system frequency
  - the thresholds that apply for load and generation events
  - the limit in the FOS on accumulated time error
- improvements to the structure and consistency of the FOS document
- other issues related to the FOS as determined by the Panel.

The Terms of reference required that the Review be completed by 31 March 2019. In March 2019 the Panel wrote to the AEMC to request a one month extension to this completion date, to allow the Panel to consider issues raised by stakeholders in response to the draft determination for stage two of the Review. The Commission approved this request and extended the date for completion of the Review to 30 April 2019.

The Terms of Reference for this Review can be seen in Appendix B.

## 1.3 Timetable for the Review

In carrying out this review, the Panel followed a consultation process that is consistent with clause 8.8.3 of the NER and the Terms of Reference. The Panel has consulted with stakeholders through seeking submissions to the issues paper, stage one draft determination and stage two draft determination.

The Panel has undertaken this review in a staged manner. This staged approach reflected the various reviews of market and regulatory arrangements that related to the Panel's assessment of the FOS.

Stage one of the Review concluded on 14 November 2017. The Final determination for stage one considered amendments to the FOS in light of the *Emergency frequency control scheme rule change*, including the introduction of the protected event contingency category and a number of other technical changes to the FOS.[2]

Following the completion of stage one, the AEMC requested that the Panel suspend progress on stage two of the review due to the interactions with the AEMC's *Frequency control frameworks review*. On 26 July 2018, the Commission published a final report for the *Frequency control frameworks review,* and at the same time provided the Panel with a revised terms of reference for completion of stage two of the review of the FOS. The revised terms of reference extended the completion date for stage two of the review from 31 July 2018 to 30 March 2019.

Stage two of the Review includes a general consideration of the appropriateness of the various components of the FOS, including the settings of the frequency bands and time requirements for maintenance and restoration of system frequency following contingency events. Stage two also includes a consideration of unresolved issues raised through the consultation process for stage one.

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

## 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 consulted directly with AEMO to support development of this determination and the FOS, for stage two of the review.

The extent of AEMO's advice is described in further detail in section 3.3 and in each of the relevant sections in chapter 4.

## 1.5 Structure of the final determination

- 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 Panel's considerations on key elements of the FOS considered through stage two of the review.
- Chapter 5 describes a number of issues, identified and considered through this review, which may require further consideration in future reviews of the FOS

# 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.

For reference, the issues paper for this review provides a detailed description of the concept of power system frequency and frequency control in the NEM.[3]

## 2.1 Related work programs

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

- Findings and recommendations from AEMO's investigation into the separation of Queensland and South Australia from the power system on 25 August 2018
- AEMC, *Frequency control frameworks review* and the related frequency control work plan
- AEMO, frequency control trials
- AEMO, *Review of the Market Ancillary Service Specification*.

The issues being covered and considered in these work programs have been relevant to the matters included in the scope of this stage 2 review of the FOS, as well as to the conclusions that the Panel has reached on some of these matters.

### 2.1.1 Queensland and South Australia system separation on 25 August 2018

**Overview of the event**

On Saturday 25 August 2018 at 13:11, the New South Wales-Queensland Interconnector (QNI) tripped, separating Queensland from the rest of the NEM.[4] The QNI trip caused power system frequency to drop in New South Wales, Victoria and South Australia. This frequency drop, combined with changes in the power flow on the Heywood Interconnector, led to the activation of the Heywood Emergency Control Scheme and separation of South Australia from Victoria.[5]

This separation caused a further reduction in power system frequency in Victoria and New South Wales, which triggered emergency UFLS in these regions to restore the balance of supply and demand. In total, there was approximately 997.3 MW of under-frequency load shedding in Victoria and New South Wales.

**AEMO findings and recommendations**

AEMO has identified that the operating incident that occurred in the NEM on 25 August 2018 was a significant system event and, while most power system equipment operated within the standards set under the NER, AEMO's view is that the aggregated response did not meet expectations for power system frequency resilience. AEMO's analysis highlights a decline in

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

4 QNI comprises two circuits strung on single tower structures. Prior to this event, QNI was not considered vulnerable to lightning as there was no 'probable' risk of simultaneous strikes impacting both lines.

5 AEMO, Final Report – Queensland and South Australia system separation on 25 August 2018, 10 January 2019.

frequency control capability and system resilience to events larger than single credible contingencies in the NEM. AEMO considers this an immediate risk to the power system.[6]

AEMO also stated that the occurrence of this event demonstrated a substantial reliance on automatic load shedding to rebalance supply and demand following contingency events in excess of the single largest credible contingency event. AEMO stated in the final operating incident report:[7]

> AEMO has identified two key factors that increased the reliance on load interruption to rebalance power system demand with supply on 25 August 2018:
>
> - Limited or no primary frequency control response from many generators — noting there is no regulatory obligation and no commercial incentive to provide frequency control other than through existing FCAS markets.
> - The distribution of FCAS reserves across the NEM at the time of the event — the allocation of contingency and regulation FCAS reserves does not usually include any need for geographic distribution. In this event there were significant differences between the needs of the power system, and the distribution of frequency response enabled via FCAS markets.

The operating incident report includes eight recommendations, including some intended to improve the resilience of the power system to contingency events in excess of the largest credible contingency event.

AEMO's principal recommendation in the final incident report is the implementation of interim actions, through rule changes as required, to deliver sufficient primary frequency control in the NEM. This recommendation is consistent with the actions set out in the frequency control work plan published as part of the final report for the AEMC's *Frequency control frameworks review* in July 2018. AEMO has proposed to work with the AEMC, AER and generators to finalise suitable interim measures by Q3 2019. AEMO will also support work on a permanent mechanism to secure adequate primary frequency control, with the aim of identifying any required rule changes to be submitted to the AEMC by the end of Q3 2019 with a detailed solution and implementation process completed by mid-2020.[8]

Other recommendations from the investigation into the separation events on the 25 August 2018 that directly relate to frequency control for the national electricity system include:[9]

- AEMO to investigate the opportunity for automating the reconfiguration of its systems including AGC and NEMDE after separation and large system events. AEMO to report on options to industry in Q2 2019.
- AEMO to investigate whether a minimum regional FCAS requirement is feasible, or whether there may be scope to manage frequency requirements arising from non-

6 AEMO, Final report - Queensland and South Australia system separation on 25 August 2018, January 2019.
7 Ibid, pp.6-7.
8 Ibid, p.8.
9 Ibid.

credible regional separation under the protected events framework in the NER after interim PFC outcomes at the end of Q3 2019.

- AEMO to work with participants to obtain information required to fully and accurately model generator frequency response and all other active power controls.

### 2.1.2 AEMC Frequency control frameworks review

On 26 July 2018, the AEMC published a final report for the *Frequency control frameworks review.* The final report outlined the Commission's analysis, conclusions and recommendations in relation to five areas related to frequency control, as listed below.

- **Frequency control during normal operation**. Frequency performance under normal operating conditions, within the normal operating frequency band (49.85Hz – 50.15Hz), has been deteriorating in recent times, primarily as a result of generators decreasing or removing their responsiveness to minor frequency deviations. The AEMC report concluded that there is a need to find a more permanent solution for the provision of sufficient primary frequency control to support frequency regulation during normal operation.
- **Future FCAS frameworks.** Including consideration of how and when to most appropriately incorporate fast frequency response and longer-term options to facilitate co-optimisation of energy, FCAS and inertia.
- **Frequency monitoring and reporting, and forecasting.** The AEMC proposed two rule change requests to promote transparency of the frequency performance of the power system and the competitiveness of FCAS markets.
- **Participation of distributed energy resources in system security frameworks.** Including the potential for distributed energy resources to provide system security services.
- **AEMO's market ancillary services specification (MASS).**[10] The AEMC set out a number of issues that AEMO should consider in its upcoming review of the MASS, including whether the time specifications for contingency services as currently set out in the MASS (i.e. 6 seconds, 60 seconds and 5 minutes) will continue to be fit for purpose as the energy system changes.

#### Frequency control work plan

The final report for the *Frequency control frameworks review* identified a number of outstanding issues which still need to be addressed, together with a longer term collaborative work plan for frequency control in the NEM.[11] Related aspects of the work plan include:

- AEMO will undertake a range of actions in an attempt to:
  - better understand the drivers of the recently observed deterioration of frequency control performance
  - reverse this deterioration, or at the very least halt any further deterioration

10 The MASS underlies the provision of market ancillary services (i.e. FCAS) in the NEM. It sets out the detailed specification for each of the market ancillary services and how a market participant's performance is measured and verified when providing these services,

11 AEMC, Frequency control frameworks review - final report, 26 July 2018, p.57-65.

- the AEMC will consult on potential longer-term mechanisms for the procurement of a primary regulating response and other frequency services as the needs of the power system evolve
- the AEMC will consider, and consult with stakeholders on, how the frequency requirements in relation to the maintenance of a satisfactory operating state are specified in the NER and the frequency operating standard. This includes consideration of whether the NER or the frequency operating standard should:
  a. prescribe in more detail the required frequency performance within the normal operating frequency band
  b. include a system standard in relation to the rate of change of power system frequency.

### 2.1.3 AEMO frequency control trials and developments

Frequency performance under normal operation has been deteriorating in recent times, evidenced by a flattening of the distribution of frequency within the normal operating frequency band. This degradation has been documented by AEMO in its recent frequency monitoring reports, along with investigations conducted through its Ancillary Services Technical Advisory Group (ASTAG), including an analysis of frequency control performance in the NEM under normal operating conditions prepared for AEMO by DIgSILENT.[12]

In response to the observed degradation of frequency performance during normal operation, the findings of the investigation into the operating incident that occurred on 25 August 2018 and the related withdrawal of active primary frequency response where it is not enabled through the FCAS markets, AEMO has an active work program to identify areas for improvement in relation to the management of frequency in the national electricity system. This work program involves potential changes to the NER, changes to AEMO procedures and a series of frequency control trials. The goal of these trials is to investigate how changes to operating practices for frequency control impact frequency performance in the NEM and the characteristics and costs of corrective actions. Specific actions within this work program include:

- **AEMO survey of generator frequency response settings**

  Over 2017, AEMO conducted a survey of generators to explore frequency responsiveness of the NEM generating fleet. Analysis of the data collected through this survey shows that around 13,000 MW of the generation capacity surveyed had dead bands set within the normal operating frequency band, with approximately 40,671 MW of capacity had dead bands set outside of the normal operating frequency band and would not therefore be considered frequency-responsive within the range of frequency between 49.85Hz and 50.15Hz. A wider dead band means that these generators will not provide an automatic response to a frequency disturbance until frequency has moved further away from the

12 DIgSILENT, Review of frequency control performance in the NEM under normal operating conditions, final report, 19 September 2017.

nominal 50Hz, or at least until the frequency has moved outside of the dead band settings for that generator.[13]

- **Primary frequency control trial in the Tasmanian power system**

  During May 2018, AEMO, in conjunction with Hydro Tasmania and TasNetworks, ran a series of frequency control trials in Tasmania. These trials involved changes to governor settings on Hydro Tasmania generating units, and to AEMO's AGC system. The effect on frequency control in the Tasmanian power system under normal operating conditions was assessed, as was the effect on the operation of Hydro Tasmania generating units.

  These tests demonstrated the key role of governor dead-bands settings in managing system frequency performance. The narrowing of governor dead-bands during the trial resulted in the frequency being held more tightly around 50 Hz.[14]

- **Regulation FCAS trial in the mainland NEM**

  Through October and November 2018, AEMO ran a regulation frequency control trial, which involved AEMO increasing the baseline of regulation FCAS by 30 MW in the mainland NEM and measuring the effect on power system frequency.[15]

  Over the course of the trial frequency performance was not measurably different to the preceding months. However, following the return to pre-trial levels of regulation FCAS, power system frequency control declined significantly. This led to a reconsideration of the results of the trial, indicating that the increase in regulation FCAS may well have prevented power system frequency from worsening during the trial period.

- **Changes to Regulation FCAS volumes in the mainland NEM**

  In January and February 2019, AEMO was not able to maintain frequency within the NOFB in line with the FOS. In response to this degradation of frequency performance and to ensure ongoing compliance with the requirements of the FOS, AEMO increased the base procurement of raise and lower regulation FCAS in the mainland NEM by 50 MW, commencing 22 March 2019.[16] Following this change the base quantity of the raise regulation service was increased from 130 MW to 180 MW and the base quantity for the lower regulation service increased from 120 MW to 170 MW. AEMO intends to review power system frequency performance every four weeks on an ongoing basis, and decide whether to further increase or hold the amount of regulation FCAS procured in order to have confidence that it can meet the requirements of the FOS for frequency performance during normal operation.

- **Primary frequency control trial in the mainland power system**

  As per the AEMO-AEMC frequency control work plan, AEMO is considering undertaking a trial of primary frequency control in the mainland power system similar to the primary frequency control trial completed in the Tasmanian power system in May 2018. The Panel

13 AEMC, Annual Market Performance Review, 4 April 2019, pp. xxxi - xxxii.

14 AEMC, Frequency control frameworks review — final report, 26 July 2018, pp.73-77.

15 AEMO, Market notice — 64715, 5 October 2018.

16 AEMO, Market notice 67823, 21 March 2019.

understands that arrangements for trials related to primary frequency control in the mainland NEM are currently on hold following AEMO's investigation into the separation event that occurred in the NEM on 25 August 2018. AEMO is focussing on actions related to the provision of primary frequency control in the NEM in line with the findings and key recommendation from the investigation into the separation event that occurred in the NEM on 25 August 2018, as discussed in section 2.1.1.

### 2.1.4 AEMO review of the Market Ancillary Service Specification

AEMO is in the process of preparing to commence a review of the market ancillary service specification (MASS). This preparation so far includes a public consultation on the scope of the review. The proposed scope includes considering change to the MASS to improve the following:

- document clarity and purpose
- clarification of the performance criteria for different methods of contingency response, such as switched or proportional response
- coordination of different market ancillary services
- consideration of acceptable speed and strength of response
- addressing barriers for new technologies
- measurement and verification of service delivery.

The Panel understands that AEMO intends to publish a consultation paper for this review in mid 2019.

# 3 ASSESSMENT APPROACH

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

## 3.1 Objective of the review

In undertaking the Review of the FOS, the Panel has been guided by the National electricity objective (NEO) which is set out under section 7 of the National Electricity Law (NEL). The NEO is as follows:

"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 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 has therefore given consideration to the following factors:

- 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. 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 build, operate and maintain their generating systems in accordance with access 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 has considered 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 has exercised 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 have been central to the Panel's consideration of the FOS in this review.

## 3.2 Scope of the Review

The Panel has undertaken this review over two stages to accommodate interactions with related work programs. Following completion of stage one of the review in November 2017, the AEMC requested that the Panel postpone consideration of stage two of the *Review of the Frequency operating standard* while the Commission progressed its *Frequency control frameworks review*.

Through submissions to stage one of the review, a number of stakeholders recognised the linkages between the Panel's *Review of the Frequency operating standard* and the AEMC's *Frequency control frameworks review*.[17] Furthermore, a number of stakeholders commented that the assessment of the setting in the FOS in relation to normal operation 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.[18]

In stage two of the FOS review, the Panel has assessed and resolved the remaining issues identified in stage one of the review, except for the following issues that are being considered by the AEMC as part of its ongoing frequency control work program following on from the *Frequency control frameworks review*:

- Reviewing the requirements in the FOS for frequency performance during normal operation
- Consideration of the inclusion in the FOS of a standard for the rate of change of frequency in the power system

The remaining issues that the Panel has considered through stage two of the review of the FOS and which are documented in this determination are:

- the limit that applies to the largest generation event in Tasmania
- the settings in the FOS that relate to contingency events
- the limit on accumulated time error
- the structure and consistency of the FOS document.

The Panel's consideration of these issues is set out in chapter four of this determination.

## 3.3 AEMO advice

The Panel has sought and received relevant technical advice from AEMO relating to the operation of the NEM power system.

A summary of the AEMO advice relevant to the issues for consideration in stage two of the FOS review is included in the relevant sections of Chapter 4.

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

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

# 4 ISSUES CONSIDERED IN STAGE TWO OF THE REVIEW

This chapter sets out the Panel's assessment of the following issues:

- Section 4.1 discusses the limit that applies to the largest generation event in Tasmania
- Section 4.2 discusses settings in the FOS that relate to contingency events including the frequency bands for generation and load events in the mainland
- Section 4.3 discusses whether the limit on accumulated time error should be revised or removed.
- Section 4.4 discusses changes to the structure of the FOS document to improve clarity and consistency.

## 4.1 The limit on the largest generation event in Tasmania

### BOX 1: THE LIMIT ON THE LARGEST GENERATION EVENT IN TASMANIA — SUMMARY OF THE PANEL'S DETERMINATION

The Panel has determined a FOS that includes a revision to the definition of a generation event and a revision to the clause setting out the limit that applies to the largest generation event in the Tasmanian power system. These changes clarify the scope of the limit in relation to the operation of the Tasmanian power system.

The revised definition of a generation event includes the disconnection of generation as a result of a credible contingency event in relation to a dedicated connection asset providing connection of one or more generating systems to the shared transmission network.

The specific changes to the associated components of the FOS are:

1. That part three of the definition of *generation event* in the FOS be revised to include:

"the *disconnection* of *generation* as the result of a *credible contingency* event (not arising from a load event a network event, a separation event or part of a multiple contingency event) in respect of either a single *generating system* or a single *dedicated connection asset* providing *connection* to one or more *generating systems*."

2. The FOS has been amended from the draft determination so that the limit on 144MW on the size of the largest generation event in the FOS for Tasmania has been revised to clarify:

- where the limit is to be measured
- that the limit applies for disconnection of generation based on an initially intact network, in the absence of network outages
- the arrangements that allow for the limit to be met in relation to one or more generating system with a combined capacity in excess of 144MW

In full, the wording for the limit in row 8 of table A.2 in the FOS is:

"The size of the largest single **generation event** in the absence of any *transmission element outage* is limited to 144 MW measured:

a) at the *connection point* for a *generating system;*

b) at the *connection point* for one or more *generating systems* in an *identified user group* which share a *dedicated connection asset*.

This limit can be implemented in relation to any *generating system* with a capacity greater than 144 MW, or to one or more *generating systems* with a combined capacity greater than 144 MW which are *connected* to the *transmission network* by a *single dedicated connection asset,* by automatic *load shedding* or any other arrangements approved by *AEMO* that would effectively reduce any **generation event** in relation to the relevant *generating system(s)* to 144MW or below."

As is the case for the existing limit, the following note applies to this clause:

"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."

The remainder of this section is structured as follows:

- Section 4.1.1 provides a background for the limit in the FOS for the largest generation event in the Tasmanian power system
- Section 4.1.2 provides a summary of stakeholder views based on submissions received in response to the draft determination for stage two of the Review
- Section 4.1.3 provides a summary of AEMO advice in relation to the limit in the FOS for the largest generation event in the Tasmanian power system
- Section 4.1.4 provides a summary of the Panel's considerations in relation to the changes to the definition of a generation event and the limit in the FOS for the largest generation event in the Tasmanian power system

### 4.1.1 Background

A.2.2 part (i) of the FOS for Tasmania includes a limit of 144MW for the maximum size of a single generation event in the Tasmanian power system:

> 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.

The contingency size limit for Tasmania was introduced by the Reliability Panel in 2008 in order to mitigate the cost impacts associated with the procurement of contingency FCAS, due

to plans to tighten the FOS for Tasmania to support the connection of the 210 MW Tamar valley CCGT power station.[19]

NEMMCO's advice to the 2008 review stated that in the absence of measures to limit the size of a credible contingency associated with the Tamar Valley PS, there may be shortages of 6 second raise FCAS in the Tasmanian power system leading to the need for market interventions to maintain a secure operating state.[20]

The limit in the FOS on the size a generation event requires AEMO to plan and operate the system such that the single largest generation event does not exceed 144MW. The limit includes provision for the operation of a generating system in excess of 144MW through having in place arrangements for the automatic tripping of load if the generating system disconnects as a result of a generation event.

During the 2008 review, the Panel considered applying the limit to network events and determined not to do so. At that time the Panel considered that the aggregate amount of time that a network event would drive the procurement of contingency FCAS to cover a loss of generation in excess of 144MW was expected to be relatively low and as such it was appropriate that the limit did not apply to network events and that these events be managed through the procurement of contingency FCAS.[21]

**Existing definitions for network and generation event in the FOS**

The current definition of a generation event that applies for both Tasmania and the mainland is:

> 1. a synchronisation of a generating unit of more than 50 MW, or
>
> 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
>
> 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.

The current definition of a network event that applies for both Tasmania and the mainland is:

> a credible contingency event other than a generation event, a separation event or a part of a multiple contingency event

**Operationalisation of the existing limit**

The current limit in the FOS on the size of the largest generation event in Tasmania is a limit that is relevant to the operation of the Tasmanian power system by AEMO. The goal of the

19 AEMC Reliability Panel, Tasmanian frequency operating standard review — final report, 18 December 2008, p.16.

20 NEMMCO, Final advice on the Tasmanian frequency operating standards, 26 August 2008, pp. 2-5.

21 In 2008 the Panel considered the impact of network events that had the potential to result in a loss of generation in excess of 144MW. Two such events were (and are), the failure of the remaining circuit during a planned outage of the dual circuit Gordon to Chapel Street transmission line; and the failure of the single circuit transmission line that connects the Musselroe wind farm to the Tasmanian transmission system. AEMC Reliability Panel, *Tasmanian frequency operating standard review — final report*, 18 December 2008, p.25.

limit is to cap the size of a generation event that drives the demand for contingency raise services required to maintain a secure operating state in Tasmania. In order to meet this limit during operation, AEMO may constrain the output of the relevant generating system(s) in Tasmania such that the largest generation event does not exceed 144 MW.

A generator can mitigate the effective size of a generation event relating to its generating system(s) through the procurement of contracted load shedding to account for the disconnection of the relevant generating system(s). This type of emergency frequency control scheme (EFCS) operates to effectively limit the size of the maximum contingency for which AEMO must purchase contingency FCAS to 144MW.

One example of such an arrangement is the Tamar valley generator contingency scheme (TVGCS). The aim of the TVGCS is to restrict the effective contingency size for the disconnection of the Tamar Valley Power station to 144 MW. If the generator trips when it is producing more than 144 MW, the TVCPS will simultaneously trip load blocks. Currently, there are four contracted commercial load blocks. There are also constraint equations for the maximum output of the Tamar Valley Generator, such that the maximum output is constrained depending on the quantity of interruptible load available to the TVGCS.[22]

**TasNetworks proposal**

The TasNetworks submission to the issues paper for stage 1 of the FOS review requested that the Panel consider extending the current limit on the size of a generation event to also apply to network events that result in the disconnection of generation. This request was based on TasNetworks' view that more renewable generating systems are intending to connect to the Tasmanian power system, resulting in situations where the combined size of the generating units behind a single transmission element will exceed 144MW. TasNetworks stated in its submission that this arrangement is not able to be captured by the existing definition of generation event and the corresponding limit of 144MW.[23]

TasNetworks provided the example of the Musselroe Wind Farm, which commenced operation in 2013 with a rated system capacity of 168MW. Musselroe is connected to the main Tasmanian transmission network at the Derby substation by a single circuit radial [110 kV] transmission line. The failure of the Musselroe — Derby line when Musselroe is at full output is the largest single credible contingency event in the Tasmanian system, in the absence of network outages.

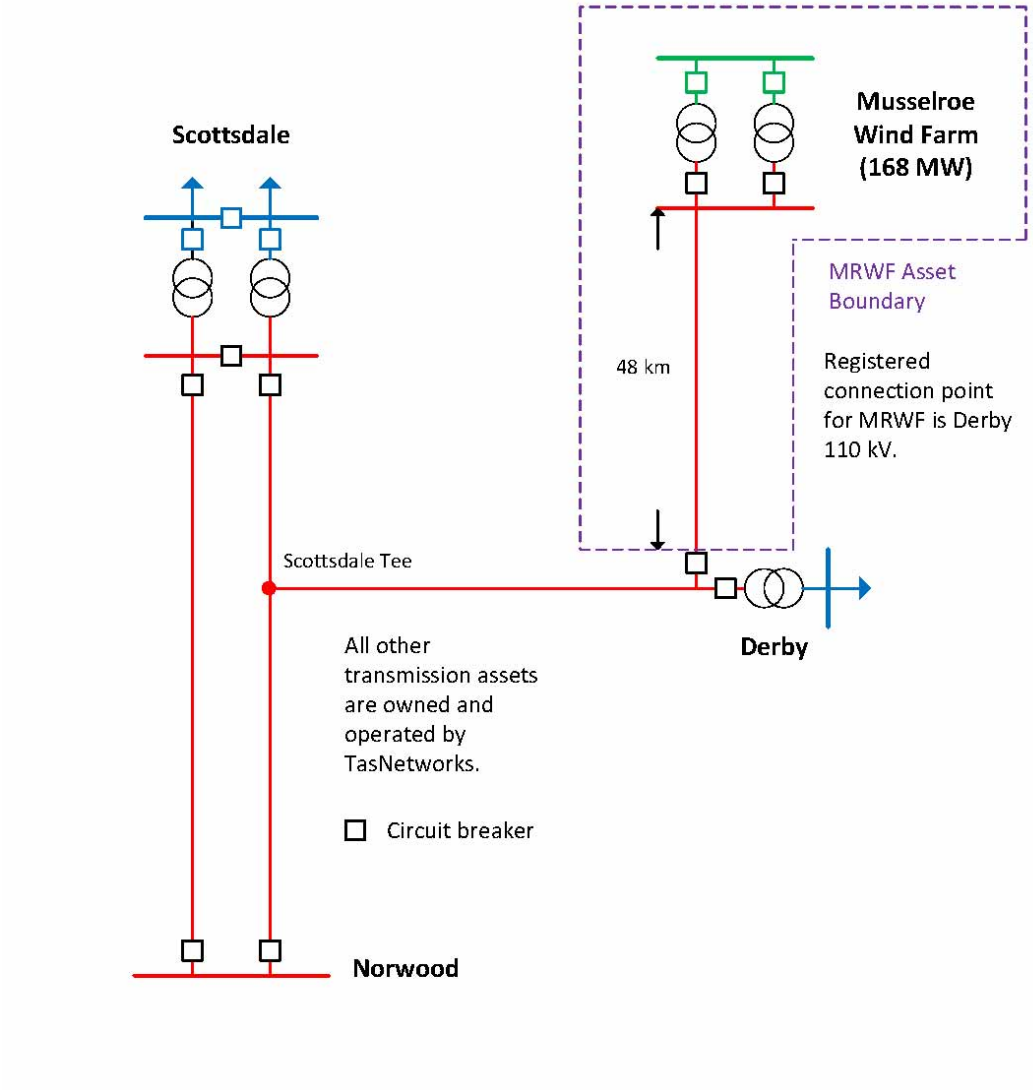
The dedicated connection asset for Musselroe wind farm was not previously covered by the definition of a generation event. As shown in figure 4.1, Musselroe wind farm incorporates duplicate transformers to reduce the size of a credible contingency impacting the generating system to below 144MW. Furthermore, under the current FOS, a trip of the Musselroe —

22 AEMO, Power system frequency risk review report, June 2018, p.43.

23 TasNetworks, Submission to the Issues Paper, pp.2-5.

Derby line is considered to be a network event not a generation event and hence the limit on the size of a generation event does not apply for the credible loss of this line.[24]

**Figure 4.1: Musselroe wind farm connection arrangement**




Source: TasNetworks

24 There are two independent credible contingency events that can result in the disconnection of the Musselroe wind farm. They are the tripping of the Musselroe — Derby line and the tripping of the Derby – Scottsdale line. TasNetworks advise that the Musselroe — Derby line is a dedicated connection asset and is not part of the shared transmission network. The Derby — Scottsdale line is part of the shared transmission network.

In its submission to the Issues paper, TasNetworks presented analysis to demonstrate that Musselroe wind farm generates in excess of 144MW approximately 16% of the time. This drives the procurement of additional contingency raise FCAS that would not be required if the limit on the size of a generation event applied to such a case.[25]

To capture these kinds of arrangements in the future, TasNetworks therefore proposed that:[26]

> a) The existing 144 MW limit be applied to all categories of single credible contingency events affecting individual generating units or generating systems. Network contingency events should be included to prevent large (>144 MW) generating systems connecting to the network via single radial transmission circuits, without the provision of load shedding facilities that can appropriately limit the resulting FCAS requirements.
>
> (b) The requirement should be applied for normal 'intact' network operating conditions, i.e. with all transmission elements initially in service, as is the situation for the vast majority of the time.
>
> (c) TasNetworks is of the view that forced or planned network outages that then expose a larger amount of generation (>144 MW) to a subsequent single contingency event can be managed by the application of interim (short term) constraints that reflect an economic and practical trade-off between resulting FCAS requirements (and subsequent costs to the market), FCAS availability and a desire to minimise operational constraints for affected generators. TasNetworks is of the understanding that AEMO utilises a similar approach to this already, with a maximum contingency size of approximately 250 MW being applied during abnormal system operating conditions.

TasNetworks proposed that this goal be achieved through the revision of the definition of a generation event as per the following:[27]

> the synchronisation of a generating unit of more than 50 MW or a credible contingency event which results in the disconnection of generation from the network.

TasNetworks set out a number of potential approaches to reflect the fact that the maximum contingency size of 144MW is not currently applied to Musselroe wind farm.[28] The options identified by TasNetworks in its submission to the issues paper were:[29]

1. limit the size of a generation event to 144MW in respect of new connecting generating systems (in the absence of load shedding schemes) and accept that Musselroe wind farm will at times exceed this value.
2. Limit the size of a generation event to 155MW as measured at the connection point for all generating systems in Tasmania. TasNetworks noted that when transmission losses

25 TasNetworks, Submission to the Issues Paper, pp.2-5.

26 Ibid.

27 Ibid.

28 Ibid.

29 The Panel notes that operational decisions as to how dispatch constraints are applied in the NEM remains at the sole discretion of AEMO.

between Musselroe wind farm and its registered connection point at Derby substation are accounted for, the impact to the Tasmanian system of the disconnection of Musselroe wind farm at full output(168MW) is approximately 155MW.

### 4.1.2 Stakeholder Views

**Overview of the draft FOS**

The draft FOS included changes to the definition of generation event to include a dedicated connection asset that is used to provide connection for one or more generating system to the shared transmission network. This change would have the effect that a generating unit or units connected by a dedicated connection asset would be covered by the limit on the largest generation event in the Tasmanian power system.

In the draft Tasmanian FOS, the limit on the size of the largest generation event was set at 144WM, measured at the connection point for a generating system or the point of common coupling to the shared transmission network where more than one generating systems share a dedicated connection asset.

**Summary of stakeholder feedback on the draft FOS**

Most stakeholders were supportive of the changes in the draft FOS in relation to the definition of a generation event and limit on the size of the largest generation event for the Tasmanian power system.[30]

However a number of stakeholders noted that the changes in the draft FOS related to the limit on the size of the largest generation event in the Tasmanian system would likely have a significant commercial impact on the operation of Musselroe wind farm.[31] These stakeholders suggested that it may be appropriate for Musselroe wind farm to be excluded or exempted from the application of the revised limit on the largest generation event in the Tasmanian power system.[32]

The AEC listed the following reasons why Musselroe should be exempt from the application of the limit on the largest generation event in Tasmania:[33]

- The generator investment was made in good faith under the previous definition;
- The amount of exceedance of the maximum generation event is small – only 13 MW after allowing for losses – and occurs infrequently;
- The generator has been operating for five years under the existing definition with no obvious impact on the integrity of the Tasmanian network

Woolnorth Holdings, which own and operate Musselroe wind farm, stated that the proposed changes to the FOS in relation to the application of the limit on the size of the largest

30 Submission to the stage two draft determination: Australian Energy Council, p.2; Hydro Tasmania, p.1; TasNetworks, p.1-2; Meridian Energy, p.1.

31 Submission to the stage two draft determination: Australian Energy Council, p.2; Hydro Tasmania, p.1; TasNetworks, p.1-2; Meridian Energy, p.1; Woolnorth Holdings, p.1.

32 Ibid

33 Australian Energy Council, Submission to the stage two draft determination, p.2.

generation event in the Tasmanian power system would threaten the future viability of its business.[34] [35] Woolnorth set out a number of reasons why they believe that it was not appropriate to apply the 144MW limit to the operation of Musselroe wind farm, including:

- The 168MW Musselroe wind farm has operated in Tasmanian power system in since 2013 without any identified negative impact on system security in the Tasmanian power system. Woolnorth state that:[36]

  > A review of several contingency and market events demonstrates that the network, if appropriately configured, can cope with the loss of Musselroe during peak generation.

- The economic effect of procuring FCAS to cover for the loss of Musselroe wind farm is mitigated to some degree by the operational control exerted by Hydro Tasmania over the output of Musselroe and Bluff point/Studland bay. Woolnorth state that:[37]

  > Hydro Tasmania also manages the FCAS requirement by remotely reducing generation at Musselroe and at times Bluff Point/Studland Bay to as low as 90 MW to meet the next largest generator requirements.

- The size of a generation event may be more accurately measured based on the loss of generation measured at the regional reference node (RRN), accounting for losses within the transmission system. Under such an arrangement the loss of Musselroe wind farm at maximum output of 168MW would represent a loss of 144.6MW, measured at the RRN.[38]

Furthermore, Woolnorth Holdings suggested that:[39]

> the largest generator event limitations on generation should be a dynamic value based on actual raise services available at the time rather than a fixed generation limit to enable optimisation of the energy markets.

The Panel's response to these stakeholder comments is included below in section 4.1.4.

### 4.1.3 AEMO advice

The Panel sought advice from AEMO on the appropriate setting for the limit on the size of the largest generation event in the Tasmanian power system.

AEMO's advice notes that this issue has two separate but related parts that must be considered carefully:

i. harmonisation of the treatment of generation and network events

ii. revisions of the actual MW limit that applies to contingency events in Tasmania.

---

34 .
35 Woolnorth Holdings, Submission to the stage two draft determination p.2.
36 Woolnorth Holdings, Submission to the stage two draft determination, pp.3-5
37 Woolnorth Holdings, Submission to the stage two draft determination, pp.3,6.
38 Woolnorth Holdings, Submission to the stage two draft determination, pp.8-9.
39 Woolnorth Holdings, Submission to the stage two draft determination, p.8.

AEMO has provided advice to the Panel that it supports the harmonisation of the Tasmanian generation and network event definitions where possible. However, AEMO recommends caution regarding any increase of the size of the limit on the largest generation event for the Tasmanian power system from the current setting at 144MW. AEMO believes revision of the limit should be carefully considered by all affected parties before implementation, and only implemented if the parties collectively agree that the limit can be successfully managed.

AEMO notes that the existing arrangements recognise that the occurrence of an event exceeding the current limit, such as the loss of the Musselroe wind farm under full output, would be relatively rare. However, revising the nominal event size limit upwards from 144MW would make this normal practice rather than an exception. AEMO also notes that there are several new large renewable generators that are in the process of making arrangements for connection to the Tasmanian power system which may lead to less synchronous generation typically available to manage frequency.

### 4.1.4 Analysis and Assessment

The Panel recognises that the existing wording of the limit in A.2.2 part (i) of the FOS for Tasmania refers to the "size of the largest single generator [generation] event" and as such does not cover the occurrence of a network event. Such an option was considered by the Reliability Panel in the 2008 determination of the frequency operating standard for Tasmania. At that time the Panel considered that "periods where the network contingency exceeds 144 MW would be relatively low as it would either be associated with a network outage or ideal wind conditions." [40]

The Panel is not aware of evidence that supports the reopening of the 2008 Panel decision that the limit on contingency events in Tasmania should apply to generation events and not to network events. However, the Panel recognises that there may be grounds for clarifying the boundaries of a generation event in light of the *Transmission Connection and Planning Arrangements Rule 2017*.

**The definition of a generation event in the FOS**

The existing limit on the size of a generation event in Tasmania applies only to a generating system, but not to transmission elements that connect the generating system to the shared transmission network. Such transmission elements are not included in the current definition of a generating system, and as such are not currently included in the scope of a generation event.

The Panel considers that the definition of a generation event in the FOS should be revised to include the disconnection of generation in relation to a dedicated connection asset that provides connection of one or more generating systems to the shared transmission network.

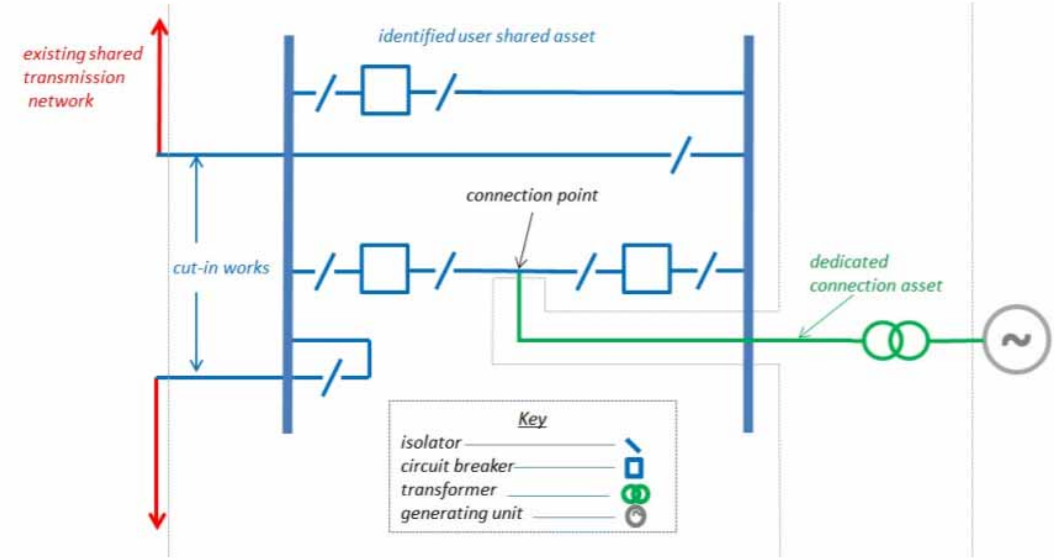
This change to the definition of a generation event is consistent with the changes to NER introduced through the *Transmission Connection and Planning Arrangements* Rule 2017. The *Transmission Connection and Planning Arrangements* Rule introduced into the NER the

40 AEMC Reliability Panel, 2008, Tasmanian Frequency Operating Standard Review - Final Report, p.25.

concept of a dedicated connection asset, which includes the collection of components that are used to connect a connecting party to the shared transmission network.[41] The equipment and plant on the generator side of a connection point includes any dedicated connection asset, such as a dedicated transmission element, along with the generating system itself.

Figure 4.2 shows a general arrangement for the connection of a generator to the shared transmission network via a dedicated connection asset.

**Figure 4.2: Generator connection to the shared transmission network via a dedicated connection asset**




Source: AEMC, *Transmission Connection and Planning Arrangements*, Rule Determination, 23 May 2017, p.6.

To reflect this situation, the Panel considers that part three of the definition of a generation event in the FOS should be revised to:

> the *disconnection* of generation as the result of a *credible contingency* event (not arising from a load event, a network event, a separation event or part of a multiple contingency event) in respect of either a single *generating system* or a single *dedicated connection asset* providing *connection* to one or more *generating systems*

**The wording and size of the limit set out in the FOS for Tasmania**

The Panel considers that the wording of the limit in the FOS for the largest generation event in the Tasmanian system should be revised to be in alignment with the proposed change to the definition of a generation event and to recognise the current operating conditions in the Tasmanian power system.

41 AEMC, Transmission Connection and Planning Arrangements, Rule Determination, 23 May 2017, p.238.

The change to the definition of a generation event clarifies that a generation event includes the disconnection of generation as the result of a credible contingency in respect of a single *generating system* or a single *dedicated connection asset,* providing *connection* to one or more *generating systems.* The revised definition is intended to cover generating systems connected to the shared transmission network via single circuit transmission elements that are dedicated connection assets, such as the Musselroe wind farm.

In the absence of network outages, the disconnection of Musselroe wind farm at full output of 168 MW is the largest credible contingency event in Tasmania that is not mitigated by automatic tripping of load. Allowing for transmission losses, the effective loss of generation as a result of the disconnection of the Musselroe wind farm under full output is 155 MW, as measured at its point of connection to the shared transmission system at the derby substation. Therefore, as noted by TasNetworks, one approach to the setting of this limit would be to standardise the limit as 155MW as measured by point of connection to the shared transmission system for a generating system.

AEMO has advised that a cautious approach should be taken in relation to any consideration of an increase of the limit from 144MW, and that such a change should not be undertaken until all affected parties have undertaken adequate consultation. AEMO note that while the Tasmanian power system currently accommodates contingency events over 144MW for a small percentage of the time, such a change would make such an operating state normal practice rather than an exception.

The Panel considers that there are a number of uncertainties associated with raising the limit on a generation event in Tasmania from 144MW to 155MW. For example, it could have material impacts in terms of changes to the quantities of FCAS to be procured by AEMO in Tasmania. In particular, the Panel understands that there may be a risk that additional volumes of FCAS may be difficult to procure in the Tasmanian region. It is also unclear what the cost impacts may be, in terms of increased FCAS costs.

Noting AEMO's advice and the uncertainties associated with changing the limit, the Panel considers that the size of the limit in the FOS for the largest generation event in the Tasmanian system in the FOS should be maintained at 144 MW, as measured at the connection point or the point of common coupling to the shared transmission network for the relevant generating system, or identified user group sharing a dedicated connection asset.[42] The revised FOS includes clarification that the limit applies for disconnection of generation based on an initially intact network, in the absence of network outages.

The wording in the FOS has been revised from that proposed in the draft FOS to clarify that the contribution from one or more generating systems, measured at the connection point, may exceed 144MW where automatic load shedding or other arrangements approved by AEMO are provided to reduce the effective size of the generation event to below 144MW. An example of such an arrangement is the automatic load shedding provided to mitigate the

42 An identified user group is defined in the NER as: "One or more persons (other than a *Network Service Provider* who is not a *Market Network Service Provider*) who, from time to time, are *connected* to a *transmission network* at the same single *connection point.*"

impact of the loss of the 208MW Tamar Valley combined cycle power station, TVGCS described in section 4.1.1.

The proposed wording for the limit on the size of the largest generation event in Tasmania as set out in row 8 of table A.2 of the FOS is:

> The size of the largest single **generation event** in the absence of any *transmission element outage* is limited to 144 MW measured:
>
> a) at the *connection point* for a *generating system;*
>
> b) at the *connection point* for one or more *generating systems* in an *identified user group* which share a *dedicated connection asset*.
>
> This limit can be implemented in relation to any *generating system* with a capacity greater than 144 MW, or to one or more *generating systems* with a combined capacity greater than 144 MW which are *connected* to the *transmission network* by a *single dedicated connection asset,* by automatic *load shedding* or any other arrangements approved by *AEMO* that would effectively reduce any **generation event** in relation to the relevant *generating system(s)* to 144MW or below.

**Response to stakeholder submissions**

The Panel notes the concerns expressed by a number of stakeholders in response to the changes included in the draft FOS in relation to the definition of a generation event and the limit on the size of the largest generation event in the Tasmanian power system. In particular, the Panel recognises that the changes to this element of the FOS are likely to have an impact on the operations of the Musselroe wind farm, owned by Woolnorth Holdings.

In response to these stakeholder concerns, the Panel has reviewed its considerations in relation to the application of the limit on the size of the largest generation event in the Tasmanian power system. Specifically the Panel has considered whether the limit should apply to the operation of Musselroe wind farm.

As set out in section 3.1, the Panel's determination of the FOS is guided by the NEO. In particular, the Panel's determination should promote the security of the national electricity system and the price, quality and security of supply of electricity. In relation to the consideration of the application of the limit on the size of the largest generation event in the Tasmanian power system and whether this limit should apply to Musselore wind farm, the Panel has considered the following:

- the ability of the Reliability Panel to grant exemptions to market participants in the FOS
- the security implications for the Tasmanian power system
- the net economic costs and benefits to Tasmanian electricity customers

***Ability of the Reliability Panel to grant exemptions in the FOS***

The Panel does not have the power under the NEL or the NER to grant exemptions or derogations for any market participant in its determination of the FOS. Nor would such a participant derogation align with the purpose of the FOS, which does not impose any

obligations on persons that are capable of being grandfathered or exempted. The FOS imposes obligations on AEMO, in relation to how the system is operated, but does not itself impose any specific obligations on any individual generators.

In contrast to the AEMC's specified rule making functions and powers in the NEL (including the power to make participant and jurisdictional derogations), the Panel's powers in relation to the FOS are to determine the standard on the advice of AEMO. There are no powers in the NEL or NER for the Panel to exempt participants from any obligations under the rules or from any standard determined by the Panel.

In addition, the purpose of the FOS is to set out the range of allowable frequency of the power system under different conditions, including normal operation and following contingency events. The FOS does not of itself impose any obligations on market participants (to which an exemption could be granted or which could be grandfathered). The FOS is applied to participants and AEMO through the rules. Therefore, any change in its application (including any exemptions or grandfathering) would have to be done by way of a Rule change.

The Panel recognises that the changes to the definition of a generation event in the revised FOS will bring the disconnection of Musselroe wind farm as the result of the tripping of its dedicated connection asset, within the scope of a generation event. This may have the effect of curtailing Musselroe's output at certain times. The security and economic impacts of this are discussed in the following sections.

***Security implications for the Tasmanian power system***

AEMO advice to the Reliability Panel for the draft determination of the FOS recommended the Panel exercise caution in relation to any upward revision to the limit on the largest generation event in the Tasmanian system.[43] The Panel understands that inclusion of Musselroe wind farm within the scope of a generation event will bring a minor improvement in the general state of system security for the Tasmanian power system as the proportion of time that a generation event over 144MW will be reduced due to the application of the limit.

***Impact on Musselroe wind farm***

Noting the possible impact on Musselroe wind farm identified by Woolnorth Holdings, the Panel sought to better understand the nature of possible economic impacts arising from the application of the 144MW limit to Musselroe wind farm. It has estimated the likely costs and benefits based on historical market outcomes. In estimating the likely operational impact for Musselroe wind farm, the Panel has accounted for electrical losses between the Musselroe wind farm terminals and the connection point located at Derby sub-station. When these losses are accounted for, the operational impact at the Musselroe generating system terminals would be close to a 152.6MW cap on generation output.[44]

43 AEMO, Advice to the Reliability Panel for stage two of the review of the frequency operating standard, 19 November 2018, p.2.

44 Calculation of losses based on analysis of network SCADA data for Musselroe wind farm terminal output and corresponding power measured at the Derby Substation.

The Panel's estimation of the potential scale of economic impacts in relation to the application of the limit on the size of the largest generation event in the Tasmanian power system includes:

- the value of the energy that would otherwise be provided by Musselroe wind farm when an operational limit of 152.6MW is applied at the terminal points for the Musselroe wind farm.
- the cost saving associated with contingency raise FCAS that would otherwise be required to cover the sudden loss of Musselroe wind farm when generating more than 152.6MW.

The results are based on market outcomes between 2015 and 2018 and are shown below:

**Table 4.1: Incremental values of energy and FCAS for Musselroe generation >155MW**

| | 2015 | 2016 | 2017 | 2018 | AVERAGE |
|---|---|---|---|---|---|
| Energy (MWh) when MR > 152.6 MW | 6,521 | 10,732 | 7,705 | 11,723 | 9,170 |
| Value ($ millions) of energy when MR > 152.6 MW | 0.3 | 0.5 | 0.6 | 0.6 | 0.5 |
| Cost ($ millions) of Raise services when MR > 152.6 MW | 0.3 | 0.5 | 1.0 | 0.7 | 0.6 |

Source: Analysis of data available through the AEMO Market management system data portal https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Data/Market-Management-System-MMS

Note: 1. Additional FCAS required to cover for incremental increase in Musselroe generation over 152.6MW based on analysis of the relationship between Musselroe output and the quantity of R6 required in Tasmania for dispatch intervals where Musselroe generation exceeds 155MW. This analysis indicates that where Musselroe generation exceeds 152.6MW, one additional MW of generation output from Musselroe wind farm drives approximately one additional MW of requirement for R6 service.

2. This analysis does not account for the impacts of marginal loss factors which are likely to discount the value of Musselroe generation.

This analysis indicates that the indicative incremental cost of the application of a 144MW limit to Musselroe wind farm is in the order of $0.5 million and the indicative incremental benefit in terms of reduced costs associated with the provision of contingency raise services is in the order of $0.6 million. This estimation of the costs and benefits of the application of a 144MW

limit to Musselroe wind farm indicates there may be a small economic benefit in the application of the 144MW limit to Musselroe wind farm.[45] The analysis does not demonstrate a material benefit in the limit being defined in such a way as to exclude Musselroe wind farm.

While this analysis of historical market outcomes gives an indication of the relative benefit of the application of the limit to Musselroe wind farm, the Panel notes that such a cost-benefit trade-off could be applied in real time as part of the market dispatch. This would involve the application of constraints in NEMDE to weigh up the incremental value of generation from the marginal generating unit, in terms of dispatch targets, against the incremental cost of providing contingency raise services to protect against the disconnection or failure of that generating unit. This form of dynamic co-optimisation of energy dispatch and FCAS requirement was mentioned by Woolnorth Holdings in its submission to the draft determination for stage two of this review and considered by the Panel when the limit was introduced in 2008.[46]

The dynamic co-optimisation of energy dispatch and FCAS requirements is neither explicitly required nor proscribed under the NER. However, the Panel considers that such an arrangement may potentially help enable the existing NER requirement for AEMO to operate central dispatch to maximise the value of dispatch offers, dispatch bids and market ancillary service offers.[47]

While the implementation of such a dynamic mechanism is outside of the scope of the Panel's powers in determining the FOS, the Panel supports and encourages further investigations being undertaken by AEMO and market participants into the appropriateness of the dynamic co-optimisation of energy dispatch and FCAS requirements in the NEM.

***Concluding remarks in response to stakeholder submissions***

In response to stakeholder submissions, the Panel has carefully considered the security and economic impacts of the changes to the definition of a generation event and the limit on the size of the largest generation event in the Tasmanian power system. The Panel has determined that the limit on the size of the largest generation event in the Tasmanian power system should apply consistently to all generating systems connected to the Tasmanian power system, without exception.

The Panel notes that under the current network access arrangement in the NEM, connecting Generators have the right to negotiate a connection to a network and pay a connection charge relating to the immediate cost of their connection to the shared transmission network. Generators do not pay for, and do not receive 'firm financial access' to the market and as such have no guarantee that they can export all of their output to the market at all times.

---

45 As noted above, this analysis does not account for the impact of system losses on the value of generation from Musselroe wind farm. The allowance for network losses between Musselroe wind farm and the regional reference node for the Tasmanian region would result in the value of the Musselroe generation being discounted by the Marginal loss factor (MLF). The MLF for Musselroe wind farm for the 2017-18 financial year was 0.9133. Ref. AEMO, Regional and Marginal loss factors: FY2017-18, 6 November 2017.

46 Woolnorth Holdings, Submission to the stage two draft determination, p.8.
AEMC Reliability Panel, 2008, Tasmanian Frequency Operating Standard Review - Final Report, p.23.

47 NER clause 3.8.1 (a), (b)

The Panel notes that the limit on the size of the largest generation event in the Tasmanian power system includes provision for the output from a generating system to exceed the limit where automatic load shedding, or other means approved by AEMO, is provided to reduce the effective size of the resultant generation event to below 144MW. This means that Woolnorth Holdings may negotiate the establishment of a generation contingency scheme, or other arrangement as approved by AEMO, that would effectively reduce the size of the associated generation event to 144MW or below. Such arrangements can mitigate the potential curtailment of Musselroe wind farm when it is able to generate in excess of 152.6MW.

**Implications for the mainland**

The Panel notes that the revised definition of a generation event in the FOS will apply for the entire NEM, including the Tasmanian and the mainland power systems. However, the limit on the size of a generation event will only apply for the Tasmanian power system.

The change of the definition of a generation event for the operation of the mainland power system, in the absence of the limit on the size of a generation event in the mainland, is not expected to impact the operation of the mainland power system.

As discussed above, this change harmonises the definition of a generation event with the intent of the NER following the *Transmission Connection and Planning Arrangements Rule 2017*. Therefore, the Panel has determined that there is no reason to include a separate definition of generation event for the mainland and for Tasmania and that the revised definition for a generation event in the FOS should apply to the entire NEM, including the Tasmanian and the mainland power systems.

In relation to the limit for the size of a generation event, the Panel is not aware of any immediate system security need for such a defined limit to apply in the FOS for the mainland power system. The Panel understands that for scenarios where the generation at risk exceeds 1.5 times the largest regional generating unit, AEMO reconfigures the FCAS constraints in NEMDE to facilitate the optimisation of the generation at risk and the dispatch of contingency FCAS.[48] Furthermore, the Panel notes that:

- the market impacts of introducing a fixed limit on the size of the largest contingency event in the mainland NEM are likely to be material and would require further analysis
- as noted in the 2008 review, "ideally the size of the contingency should be determined dynamically following an economic trade-off between the benefits of the resulting generation and the costs of the associated FCAS."[49]

Therefore the limit on the size of a generation event in the FOS applies only to the Tasmanian power system and not in the mainland.

48 AEMO, Constraint formulation guidelines, 5 December 2013, p.20.

49 AEMC Reliability Panel, Tasmanian Frequency Operating Standard Review - Final Report, 18 December 2008, p.23.

## 4.2 Settings in the FOS for credible contingency events

### BOX 2: SETTINGS IN THE FOS FOR CREDIBLE CONTINGENCY EVENTS — SUMMARY OF THE PANEL'S CONSIDERATIONS

The Panel has determined to maintain the existing settings in the FOS in relation to the management of credible contingency events in the NEM. This determination is consistent with AEMO advice that, in the context of the ongoing frequency control work program, the existing settings in the FOS that apply to the management of contingency events should be maintained.

The Panel has considered the following specific issues that relate to the settings in the FOS for credible contingency events:

- Based on the technical capability of the existing generation fleet, whether the generation and load change band, 49.5Hz — 50.5Hz that applies in the mainland NEM should be widened to be equal to the network event band and the operational frequency tolerance band, 49.0Hz — 51.0Hz.
- whether it is appropriate for the settings in the FOS that relate to the minimum thresholds for generation and load events to be refined on a regional basis to better match the regional characteristics of the power system.

This following sections set out the Panel's investigations into two aspects of the settings in the FOS for the management of contingency events:

- Section 4.2.1 provides a summary of stakeholder views in relation to the settings in the FOS for credible contingency events
- Section 4.2.2 provides a discussion of the generation and load change band in the FOS for the mainland NEM
- Section 4.2.3 provides a discussion of the minimum megawatt thresholds in the FOS for generation and load events

### 4.2.1 Stakeholder Views

The majority of stakeholders supported the Panel's draft determination to maintain the existing settings in the FOS for credible contingency events; including the generation and load change band for the mainland NEM and the minimum thresholds for generation and load events.

TasNetworks noted that:[50]

> Widening of the generation and load change bands, particularly when there are a number of ongoing work programs focused on frequency control in the NEM, would remove safety margins for stabilisation and recovery following contingency events.

50 TasNetworks, Submission to the stage two draft determination, 16 January 2019, p.2

Energy Queensland noted that any change to the generation and load change band should include consideration of both the benefits in terms of any reduction in costs associated with provision of FCAS and the costs associated with any increased probability of unserved load associated with the operation of under-frequency load shedding.[51]

### 4.2.2 Generation and load change band for the mainland NEM

The Panel has investigated the potential for the generation and load change band in the FOS for the mainland NEM to be widened from 49.5 Hz — 50.5 Hz to 49.0 Hz — 51.0 in line with the network event band and the operational frequency tolerance band.

The Panel estimates that this broadening of the generation and load change band in the FOS for the mainland NEM may lead to a reduction in the requirement for contingency FCAS, which could result in cost saving in the order of tens of millions of dollars per year. However, in the context of the ongoing frequency control work plan, described in section 2.1, and in line with AEMO advice, the Panel has determined to leave the generation and load change band in the FOS for the mainland unchanged at 49.5 Hz — 50.5 Hz at this time.

The Panel acknowledges AEMO advice that a broadening of the generation and load change band would remove current operating safety margins for stabilisation and recovery following contingency events and potentially risk the operation of under frequency load shedding following credible contingency events.

The Panel recommends that the AEMC provide it with a revised terms of reference at a later date when AEMO analysis, as set out in the frequency control work plan, is further progressed and sufficient information is available to allow the Panel to properly assess the costs and benefits of such a change to the FOS.

#### Background

The generation change band and load change band are frequency bands that set the extent to which frequency can deviate following a generation or a load event. The FOS defines the allowable frequency range for these bands as 49.5 Hz — 50.5 Hz; in this paper, these bands are referred to collectively as the "generation and load change band".

The existing generation and load change band in the FOS was set to accommodate legacy generators that connected to the power system with technical performance standards that did not meet the (then) existing minimum technical performance standards for response to a frequency disturbance. At the time, it was identified that such generators may disconnect from the power system if the frequency deviated beyond the range 49.5 – 50.5 Hz for a prolonged period.[52]

51 Energy Queensland, Submission to the stage two draft determination, 17 January 2019, p.1.

52 This issue was identified in 2001, when the Reliability Panel considered widening the generation and load change band. However, at the time it was noted that,"National Electricity Code derogations for many Victorian generating units provide that they only need to operate continuously following single generating unit loss if the system frequency remains above 49.5 Hz. While such derogations are in force, a relaxation of this frequency band would increase the probability that loss of a single generating unit would lead to total system collapse. NECA Reliability Panel, 2001, Frequency operating standards — Determination, September 2001, p.11.

In theory, if all generators connected to the mainland network were able to maintain continuous uninterrupted operation for 2 minutes within the operational frequency tolerance band, 49.0 Hz — 51.0 Hz, then it may be appropriate to widen the generation and load change band (currently 49.5 Hz — 50.5 Hz) to equal the operational frequency tolerance band.

**Analysis and assessment**

This issue relates to whether the specific bands for generation and load events in the mainland FOS should be changed, including by widening them to match the network event band and operational frequency tolerance band.

The Panel notes that any widening of the generation and load change band for the mainland, may result in a reduction of costs associated with the purchase of contingency FCAS, by reducing the amount of fast and slow contingency FCAS that AEMO needs to procure to maintain the system within the applicable frequency range. This reduction in the requirement for fast and slow contingency FCAS is due to the impact of load relief that contributes to mitigating the impact of a contingency event.[53]

The Panel estimates that this reduction in the requirement for contingency FCAS may translate into cost savings in the order of tens of millions of dollars.

However, in considering whether to revise the generation and load change band Panel must consider the operational capability of the existing generation fleet and the broader operational impacts of such a change to the FOS in the context of the broader frequency control work programs set out in section 2.1.

***Operational Capability of the existing generation fleet***

A key consideration in assessing the appropriate setting for the generation and load change band is the technical capability of generators connected to the power system to maintain operation during frequency disturbances if the power system frequency were allowed to move into wider bands.

When the Panel reviewed the FOS in 2001, the National Electricity Code included derogations for a number of Victorian generators in relation to generator response to frequency disturbances. These derogations set out that continuous uninterrupted operation was required only where the system frequency does not fall below 49.5Hz and recovers to 49.9 Hz within 4 minutes. The derogations applied to the following generation units:[54]

- Yallourn W Power station Units 1-4
- Eildon PS Units 1-2
- Clover creek PS Units 1-2

53 Load relief is the reduction in power withdrawn from the power system as a result of a fall in the system frequency. When the system frequency falls, many of the motors connected to the power system will slow down. As the amount of power consumed by these machines is proportional to their rotational speed, the demand for power seen by the power system will fall when frequency falls. Other equipment may also consume less power when the frequency falls. Conversely, if the frequency is increased, the demand for power will be seen to increase. AEMO, Constraint implementation guidelines — for the national electricity market, June 2015, pp.19-20.d

54 National Electricity Code, Version 1, Schedule 9A3 Part 6, 1 May 2003, pp.72-73.

- Hazelwood PS Units 1-8 — closed March 2017
- Morwell PS Units 1-5 — closed August 2014
- Jeeralang A PS Units 1-4
- Jeeralang B PS Units1-3
- Dartmouth PS Unit 1
- Newport D Power Station Unit 1
- McKay Creek PS Units 1-6
- West Kiewa PS Units 1-4
- Loy Yang B PS Units 1-2
- Loy Yang A PS Units 1 to 4

These derogations were transferred into version one of the NER in 2005 and were removed in 2010 as they were redundant and no longer consistent with the negotiated generator technical performance standards agreed with AEMO.[55]

The Panel has reviewed the current generator performance standards for each of the generators listed above and can confirm that these generating units are able to maintain continuous uninterrupted operation within the requirements of the FOS, not just for a generation event but also for the wider standard in the FOS for a network event, which allow for the frequency to drop as low as the level of the operational frequency tolerance band.

The applicable frequency ranges and times for stabilisation and recovery following a network event are set out in the FOS for the mainland as:

- frequency shall be not exceed the operational frequency tolerance band, 49 Hz — 51 Hz
- frequency shall be stabilised to 49.5 Hz within 1 minute and recovered to 49.85 Hz within 5 minutes.

This would indicate that the performance capabilities of the current generation fleet do not impede the widening of the generation and load change band out to 49.0 Hz — 51.0 Hz, making them consistent with the frequency band for network events and the operational frequency tolerance band.

**Increased risk of load shedding**

As identified above, the performance standards for the operational generation fleet may not be an impediment to widening the generation and load change band in the mainland. However, AEMO's advice to the Panel is that widening the generation and load change band would reduce the operating safety margin that currently exists in the FOS for the mainland NEM to allow for stabilisation and recovery of the power system following contingency events.

The operating safety margin in the existing FOS is a result of the frequency gap between the lower limit of the generation and load change band (49.5Hz) and the frequency at which automatic under frequency load shedding commences (49.0Hz). This buffer reduces the likelihood of load shedding for credible contingency events, to account for operational

55 AEMC 2010, Victoria Generator Technical Performance Standards Derogations, Rule Determination, 9 September 2010.

uncertainties and may help to reduce the quantity of load shed following a non-credible contingency.

The Panel notes the ongoing concerns and investigations in relation to frequency control during normal operation, primary frequency control and governor response and the quality of FCAS provision. This is highlighted by the recommendations stemming from the separation event that occurred in the NEM on 25 August 2018 which include that AEMO, the AEMC and the AER establish appropriate arrangements to increase the provision of primary frequency control form new and existing generators by Q3 2019.[56] The immediate priority is in the resolution of this issue along with the issues documented in the joint AEMC-AEMO frequency control work plan published as part of the final report for the *Frequency control frameworks review*.[57]

**AEMO advice**

AEMO supports the maintenance of the existing settings in the FOS that relate to the management of contingency events and strongly advises against any widening of the generation and load change band at this time. Such a change would remove current safety margins for stabilisation and recovery following contingency events and potentially place at risk under frequency load shedding.

Furthermore, there are serious ongoing concerns and a number of active work programs focused on frequency control in the NEM. Relaxing frequency control requirements in this environment would be highly counter-productive. The immediate priority is in the resolution of these issues as documented in the joint AEMC-AEMO frequency control work plan published as part of the final report for the Frequency control frameworks review.[58]

AEMO notes specifically that:

1. Load relief factors are based on historical observations and estimates; in reality load relief varies depending on the nature of the load. Increasing DER and changes in customer load mean load relief factors are not only likely to be decreasing, but becoming less predictable; work is in progress at present to re-evaluate load relief factors.
2. System settings should never be designed around an assumption of perfect frequency response delivery at all times. Rather, operational settings should make allowance for operational uncertainty.

### 4.2.3 The minimum megawatt thresholds for generation and load events

**Background**

The FOS includes separate definitions for a load event and a generation event. These definitions include a threshold size, in megawatts, that indicates the size of a contingency event above which the frequency may deviate outside the normal operating frequency band

56 AEMO, Final Report – Queensland and South Australia system separation on 25 August 2018, 10 January 2019, p.8.
57 AEMC, *Frequency control frameworks review*, Final report, 26 July 2018, pp. 57-69.
58 Ibid.

of 49.85 to 50.15 Hz(while remaining within the applicable generation and load change band in accordance with the FOS).

AEMO utilises regulating FCAS to control the system frequency within the Normal operating frequency band (NOFB), 49.85Hz — 50.15Hz. AEMO dispatch contingency FCAS to automatically operate when the frequency deviates outside the NOFB in order to rebalance supply and demand and restore the frequency to the NOFB.

The current minimum thresholds in the FOS are:

- **Load event** — 20MW(Tasmania) and 50MW (Mainland)
- **Generation event** — 50MW (Tasmania and Mainland)

The issue being considered here is the relationship between the size of an interconnected region and the size of a contingency event that would be expected to result in a frequency deviation of a certain amount. In general, a larger power system requires a larger imbalance of supply and demand (a larger contingency event) to cause the same frequency deviation, as compared to a smaller system. The relationship between variation of frequency in a power system and the size of a supply demand imbalance is called frequency bias.[59]

#### Analysis and assessment

While there may be a theoretical basis for refining the minimum thresholds for generation and load events, the Panel considers that the variation of the thresholds in the FOS for generation and load events are not likely to deliver material benefits at this time. This is because these thresholds do not result in any costs being incurred as the settings do not drive the procurement of any market ancillary services by AEMO.

The Panel notes that it may be beneficial to reassess this issue at a future date, depending on future developments in the market and regulatory arrangements for the power system. In particular, in the final report for the *Frequency control frameworks review,* the AEMC recommended the development of an explicit mechanism to incentivise the provision of primary regulating services to support good frequency performance during normal operation. In addition, the AEMC is considering how the requirement for frequency performance during normal operation is specified in the NER and the FOS. Any consideration of the thresholds would be relevant to these issues because the minimum thresholds for contingency events relate to the definition of the boundary between the types of system events or variations that should be managed within the NOFB and the larger variations for which the frequency may deviate outside the NOFB.

#### AEMO Advice

AEMO maintains that while it is possible that there may be more appropriate or dynamic settings for the minimum megawatt thresholds for generation and load events, such changes are not likely to have a material impact on how AEMO procures FCAS. Rather, AEMO's

59 Frequency bias is proportional to the quantity and type of generation and load equipment connected to the system at any time.AEMO currently use a static frequency bias for the mainland of 280MW/0.1Hz compared with 20MW/0.1 Hz for Tasmania.

immediate priority is the progression of the broader frequency control work program as set out in section 2.1.

## 4.3 The limit on maximum accumulated time error

BOX 3: THE LIMIT ON MAXIMUM ACCUMULATED TIME ERROR — SUMMARY OF THE PANEL'S CONSIDERATIONS

The Panel has determined to maintain the limit for accumulated time error that applies in the FOS for the mainland and for Tasmania at 15 seconds.

The Panel considers that further time is required to enable adequate assessment of the impact of the increase to the limit on the maximum accumulated time error for the mainland power system made in November 2017.

### 4.3.1 Background

Time error is a measure of the accumulated time the power system has spent above or below exactly 50 Hz. Maintenance of time error with a long term average value close to zero, ensures in turn that frequency control arrangements are nearly energy neutral, as there is no long term average operation of the power system above or below 50 Hz.

The final determination for stage one of the Review of the FOS relaxed the limit on accumulated time error in the mainland NEM from 5 seconds to 15 seconds, equal to the limit that applies in Tasmania. AEMO advice to stage one of the review suggested that the purchase of regulating FCAS for time error correction may have costs in the order of $1 million per annum based on analysis of data for the period January 2016 to June 2017.[60]

In the final determination for stage one of the FOS, the Panel noted the intent to continue to consult with stakeholders in relation to the potential to further relax or remove the limit on accumulated time error through stage two of the review.

### 4.3.2 Stakeholder views

The AEC recognises that accumulated time error is a useful metric for the monitoring of frequency performance over time. According to the AEC, measurement of time error is particularly useful for identifying:[61]

- systemic biases in control systems
- periods in the day where the energy market consistently fails to adequately balance supply and demand requiring an over-reliance on frequency control ancillary services.

According to the AEC: [62]

60 AEMO, Advice to the Reliability Panel for the review of the frequency operating standard, 18 August 2017, p.7.
61 AEC, Submission to the stage two draft determination, 17 January 2019, pp.2-3.
62 Ibid.

> A large time error indicates a frequency control problem that has occurred in the past but is not necessarily occurring presently. If it is large then we should look to rectify its cause in order to prevent its repetition, however there is no market or customer benefit in realigning electrical time by applying an intentional frequency bias to a subsequent, unrelated period.
>
> [...]
>
> The AEC suggests the accumulated time error limit should be re-expressed such that a rapid change triggers an investigative action but does not oblige AEMO to reduce it through intentional frequency biases upon future, unrelated dispatch intervals.

### 4.3.3 AEMO advice

AEMO provided advise to the Panel to support the Panel's draft determination, that it is in the process of implementing the recently relaxed time error standard as part of its program of work of reviewing and tuning the AGC system. Given this ongoing work, AEMO advise that the limit on accumulated time error in the FOS should not be revised further until the implementation of changes to the AGC system are complete and a suitable period of monitoring has taken place.

### 4.3.4 Analysis and assessment

AEMO have advised that it is still in the process of retuning the AGC settings which include recalibration of the settings in the AGC that relate to time error correction. As such it is not possible to assess the impact of the relaxation in November 2017 of the limit on accumulated time error in the mainland from 5 seconds to 15 seconds.

The Panel notes that maintaining a limit on accumulated time may deliver value in terms of maintaining the integrity of the energy market. Balancing accumulated time error over the long term ensures that the energy market is self-contained and frequency control arrangements do not end up being used to correct energy imbalances that may occur in the energy market.

#### Response to stakeholder submissions

The Panel notes the feedback provided by the AEC in relation to the value of measuring accumulated time error for the identification of system issues within the power system related to frequency control. The Panel also notes the AEC's views in relation to the potential limitations of benefits related to the practise of time error correction and agree that the arrangements for time error correction should be further considered in a subsequent review of the FOS.

The Panel notes that a rule change request is expected to be submitted by AEMO to the AEMC to clarify the requirements in the NER in relation to the AEMO's monitoring and

reporting of frequency performance in accordance with the FOS. As noted by the AEMC in the final report for the *Frequency control frameworks review*:[63]

> AEMO currently produces frequency monitoring reports voluntarily on a periodic basis, and has committed to do so more regularly. However, as there is no requirement for AEMO to publish such reports, there is neither consistency in how often they are published nor formal consultation on what metrics are reported against.

The Panel notes that improved transparency in relation to the performance of the power system with respect to accumulated time error and other metrics will help AEMO and market participants more readily diagnose power system issues related to frequency control.

## 4.4 Improvements to the structure and consistency of the FOS

BOX 4: IMPROVEMENTS TO THE STRUCTURE AND CONSISTENCY OF THE FOS - SUMMARY OF THE PANEL'S DETERMINATION

The FOS has been restructured and consolidated to avoid duplication and improve the clarity of the obligations that it places on AEMO to manage the power system frequency.

### 4.4.1 Background

In August 2017, AEMO provided advice to the Panel for stage one of the review, which included a request that the Panel review the structure of the FOS and its usage of terminology to improve its legal robustness and to minimise the potential for different interpretations by AEMO and other stakeholders. AEMO noted as an example that the provisions for the mainland FOS that applies during supply scarcity are included in the summary tables in part A of the mainland FOS but are not referred to in the text based detail of Part B.[64]

### 4.4.2 Stakeholder Views

Stakeholder submissions in response to the Panel's draft determination for stage two of the Review did not raise any significant objections to the revised document structure for the draft FOS. TasNetworks supported the changes to the document structure set out in the draft FOS, noting that:[65]

> the new FOS structure [...] better integrates the mainland and Tasmanian frequency operating standards into a single document
>
> [...]

63 AEMC, Frequency control frameworks review — Final report, 26 July 2018, p.44.
64 AEMO, Review of the frequency operating standard - stage 1 - request for advice, 18 August 2017, p.11.
65 TasNetworks, submission to the stage two draft determinations, 16 January 2019, p.2.

> TasNetworks considers that the revised formatting is likely to address such situations by presenting the two 'sets of standards' in a more holistic manner.

Delta Energy noted that:[66]

> the words of the standard must be carefully chosen to avoid confusion, misinterpretation and the resultant errors in application and expectation.

Delta Energy identified a number of instances in the draft FOS where the wording in the draft FOS may present interpretive questions to the reader, particularly:

1. Should the frequency requirements in the FOS prescribe the methodology, accuracy and resolution for the measurement of system frequency?
2. The use of the word "exceed" in relation to maintaining the system frequency within a particular frequency band, such as the normal operating frequency band, may open the requirement to misinterpretation. Delta suggests that use of the phrase "be maintained within" would avoid confusion.
3. The wording in table A.2 point 2 of the draft FOS, can be interpreted such that the exception for credible contingency events applies only to the recovery of the power system frequency within 5 minutes for each contingency event and does not apply to the requirement for the frequency not to be outside of the normal operating frequency band more than 1% of the time. If this is not the intent then the wording should be clarified.
4. In relation to the recovery of the system frequency to be within the normal operating frequency band within 5 minutes following a contingency event; Delta request whether the FOS should specify what constitutes the commencement and conclusion of a contingency event.

### 4.4.3 AEMO advice

As noted in the AEMO advice for stage two of the review, staff from AEMO and the AEMC worked collaboratively on the drafting of the revised FOS document to improved readability and consistency. AEMO notes that the changes in the draft FOS alter the document structure and language only and do not alter the technical nature of the standard.

### 4.4.4 Summary of changes to the document structure in the draft FOS

The Panel recognises that it is important that the frequency operating standard provides a clear and concise documentation of the power system requirements in relation to frequency. The draft FOS document has been restructured while maintaining and clarifying the key technical aspects of the standard.

The key changes in the draft FOS include:

- Changes to the document structure including a rearrangement and consolidation of the elements of the FOS

66 Delta Energy, Submission to the stage two draft determination, 17 January 2019, p.2.

- changes to the definitions in the FOS to remove duplication and improve clarity including:
  - terms that are defined in the Chapter 10 of National Electricity Rules are displayed in italics
  - terms defined locally in section A.3 of the FOS are displayed in bold text.
  - the definition of the term, "generation and load change band", has been revised to improve clarity in relation to the relative requirements for an island, during supply scarcity and otherwise
  - Footnote 5 has been included to clarify the requirements for the containment band for contingency events during a state of supply scarcity in the Mainland NEM
  - The draft FOS includes text that clarifies that the expected frequency outcomes for the Tasmanian power system during a state of supply scarcity are the same as for an intact power system.
  - The definition of supply scarcity in the draft FOS has been revised to improve the clarity of the intended meaning.

**Response to stakeholder submissions**

The Panel has considered the changes and clarifications suggested by Delta Energy and has the following responses to the issues raised:

1. The Panel does not consider that it is appropriate for the FOS to specify the methodology, accuracy and resolution for the measurement of system frequency. Such detailed specifications are more appropriately considered by AEMO in the context of its power system security responsibilities.
2. To reduce the potential for misinterpretation, the revised FOS includes changes to the wording of the clauses in table A.2 to clarify the requirements in relation to that the system frequency "be maintained within" specific frequency band or "not be outside of" specific frequency bands.
3. To reduce the potential for misinterpretation, the revised FOS includes changes to the wording in table A.2 point 2. The revised wording in the FOS is:

   "Except as a result of a *contingency event* or a **load event**, **system frequency**:

   a) shall be maintained within the applicable normal operating frequency excursion band, and

   b) shall not be outside of the applicable *normal operating frequency band f*or more than 5 minutes on any occasion and not for more than 1% of the time over any 30-day period."
4. The Panel does not consider that it is appropriate for the FOS to be amended to provide further specification in relation to the precise commencement and conclusion of a contingency event. In relation to frequency control and compliance point 2 from Table A.2 in the FOS, a contingency event conceivably commences from the moment the frequency moves outside of the NOFB and continues until the frequency recovers to within the NOFB. However, the Panel recognises that AEMO is best placed to define the specific

operational definitions in relation to the commencement and conclusion of contingency events.

The FOS is included in Appendix A.

## 4.5 The arrangements and timing for the implementation of the FOS

As noted in section 4.1.4, the Panel recognises that the changes to the FOS in relation to the definition of a generation event and the revision of the limit that applies to generation events in the Tasmanian power system are likely to have a material commercial impact on the operations of the Musselroe wind farm, owned by Woolnorth holdings. The Panel notes that this commercial impact may be partially ameliorated through the establishment of a mechanism to reduce the effective size of the generation event associated with the disconnection of the Musselroe wind farm to 144MW or less.

The Panel considers that it is appropriate to allow for a period of time, prior to the application of the revised FOS, for Woolnorth holdings to make arrangements to mitigate the commercial impact of the changes in the FOS. The Panel has received a request from Woolnorth Holdings that the implementation date for the revised standard be delayed until the end of December 2019 to allow for mitigation measures to be put in place.

The Panel notes that the goal of the changes to the definition of a generation event and the revision of the limit that applies to generation events in the Tasmanian power system is to guide the design for the connection of new generator connections in the Tasmanian region. Based on discussions with representatives from TasNetworks, the Panel understands that a short delay to the date that the revised FOS takes effect will not significantly undermine negotiations in relation to future generation connections in the Tasmanian region.

Therefore, having considered the above issues the revised FOS will take effect on 1 January 2020, as per the request by Woolnorth Holdings.

# 5 CONSIDERATIONS FOR FUTURE REVIEWS OF THE FOS

Throughout the process of reviewing and consulting on the FOS, the Panel has become aware of a number of issues that are ongoing or may warrant consideration in future review of the FOS.

The Panel notes that the following issues, identified and considered through this review, may require further consideration in future reviews of the FOS:

- **the settings that relate to credible contingency events**, considered in section 4.2.

  In this review, the Panel has determined to maintain the existing settings in the FOS in relation to contingency events. This determination is based on AEMO advice that it is not appropriate to vary these settings at the moment as the immediate priority is in the resolution of frequency control issues as documented in the joint AEMC-AEMO frequency control work plan published as part of the final report for the Frequency control frameworks review.

- **the settings that relate to accumulated time error**, considered in section 4.3.

  As part of stage one of this review, in November 2017 the Panel relaxed the limit on accumulated time error that applies in the FOS for the mainland NEM from 5 seconds to 15 seconds. In stage two of the review the Panel determined not to make further changes to this limit as further time is required for AEMO to assess the impact of the changes made to the FOS in 2017. Following a suitable period of monitoring it may be appropriate for the Panel to consider further changes to the limit in the FOS in relation to accumulated time error.

The Panel notes that, as described in section 2.1.2, AEMO and the AEMC are continuing to consider the appropriateness of the frequency control arrangements in the NEM through the joint frequency control work plan. The Panel is prepared to respond to any request from these market bodies to undertake further review of the FOS as a result of these considerations of the operational and regulatory arrangements that relate to frequency control in the NEM.

# ABBREVIATIONS

| | |
|---|---|
| AEMC | Australian Energy Market Commission |
| AEMO | Australian Energy Market Operator |
| AER | Australian Energy Regulator |
| AUFLS | Automatic under frequency load shedding |
| Commission | See AEMC |
| FOS | Frequency operating standard |
| MASS | Market ancillary service specification |
| MCE | Ministerial Council on Energy |
| NEL | National Electricity Law |
| NEO | National electricity objective |
| NOFB | Normal operating frequency band |
| NOFEB | Normal operating frequency excursion band |
| OFTB | Operational frequency tolerance band |
| PFC | Primary frequency control |

# GLOSSARY

| | |
|---|---|
| Available capacity | The total MW capacity available for dispatch by a scheduled generating unit or scheduled load (i.e. maximum plant availability) or, in relation to a specified price band, the MW capacity within that price band available for dispatch (i.e. availability at each price band). |
| Cascading outage | The occurrence of a succession of outages, each of which is initiated by conditions (e.g. instability or overloading) arising or made worse as a result of the event preceding it. |
| Contingency events | These are events that affect the power system's operation, such as the failure or removal from operational service of a generating unit or transmission element. There are several categories of contingency event, as described below:<br>• credible contingency event is a contingency event whose occurrence is considered "reasonably possible" in the circumstances. For example: the unexpected disconnection or unplanned reduction in capacity of one operating generating unit; or the unexpected disconnection of one major item of transmission plant<br>• non-credible contingency event is a contingency event whose occurrence is not considered "reasonably possible" in the circumstances. Typically a non-credible contingency event involves simultaneous multiple disruptions, such as the failure of several generating units at the same time. |
| Directions | Under s. 116 of the NEL, AEMO may issue directions. Section 116 directions may include directions as issued under clause 4.8.9 of the NER (e.g. directing a scheduled generator to increase output) or clause 4.8.9 instructions (e.g. instructing a network service provider to load shed). AEMO directs or instructs participants to take action to maintain or re-establish the power system to a secure operating state, a satisfactory operating state, or a reliable operating state. |
| Dispatch | The act of initiating or enabling all or part of the response specified in a dispatch bid, dispatch offer or market ancillary service offer in respect of a scheduled generating unit, a scheduled load, a scheduled network service, an ancillary service generating unit or an ancillary service load in accordance with NER rule 3.8, or a direction or operation of capacity the subject of a reserve contract as appropriate. |
| Distribution network | The apparatus, equipment, plant and buildings (including the connection assets) used to convey and control the conveyance |

| | |
|---|---|
| | of electricity to consumers from the network and which is not a transmission network. |
| Distribution network service provider (DNSP) | A person who engages in the activity of owning, controlling, or operating a distribution network. |
| Frequency control ancillary services (FCAS) | Those ancillary services concerned with balancing, over short intervals, the power supplied by generators with the power consumed by loads (throughout the power system). Imbalances cause the frequency to deviate from 50 Hz. |
| Interconnector | A transmission line or group of transmission lines that connect the transmission networks in adjacent regions. |
| Jurisdictional planning body | The transmission network service provider responsible for planning a NEM jurisdiction's transmission network. |
| Load | A connection point (or defined set of connection points) at which electrical power is delivered, or the amount of electrical power delivered at a defined instant at a connection point (or aggregated over a defined set of connection points). |
| Load event | In the context of frequency control ancillary services, a load event: involves a disconnection or a sudden reduction in the amount of power consumed at a connection point and results in an overall excess of supply. |
| Load shedding | Reducing or disconnecting load from the power system either by automatic control systems or under instructions from AEMO. Load shedding will cause interruptions to some energy consumers' supplies. |
| Ministerial Council on Energy (MCE) | The MCE is the national policy and governance body for the Australian energy market, including for electricity and gas, as outlined in the COAG Australian Energy Market Agreement of 30 June 2004. |
| National Electricity Code | The National Electricity Code was replaced by the National Electricity Rules on 1 July 2005. |
| National electricity market (NEM) | The NEM is a wholesale exchange for the supply of electricity to retailers and consumers. It commenced on 13 December 1998, and now includes Queensland, New South Wales, Australian Capital Territory, Victoria, South Australia, and Tasmania. |
| National Electricity Law (NEL) | The NEL is contained in a schedule to the National Electricity (South Australia) Act 1996. The NEL is applied as law in each participating jurisdiction of the NEM by the application statutes. |
| National Electricity Rules (NER) | The NER came into effect on 1 July 2005, replacing the National Electricity Code. |
| Network | The apparatus, equipment and buildings used to convey and control the conveyance of electricity. This applies to both transmission and distribution networks. |

| | |
|---|---|
| Network capability | The capability of a network or part of a network to transfer electricity from one location to another. |
| Network control ancillary services (NCAS) | Ancillary services concerned with maintaining and extending the operational efficiency and capability of the network within secure operating limits. |
| Network event | In the context of frequency control ancillary services, the tripping of a network resulting in a generation event or load event. |
| Network service providers | An entity that operates as either a transmission network service provider (TNSP) or a distribution network service provider (DNSP). |
| Network services | The services (provided by a TNSP or DNSP) associated with conveying electricity and which also include entry, exit, and use-of-system services. |
| Operating state | The operating state of the power system is defined as satisfactory, secure or reliable, as described below.<br>The power system is in a **satisfactory** operating state when:<br>• it is operating within its technical limits (i.e. frequency, voltage, current etc are within the relevant standards and ratings)<br>• the severity of any potential fault is within the capability of circuit breakers to disconnect the faulted circuit or equipment.<br>The power system is in a **secure** operating state when:<br>• it is in a satisfactory operating state<br>• it will return to a satisfactory operating state following a single credible contingency event.<br>The power system is in a **reliable** operating state when:<br>• AEMO has not disconnected, and does not expect to disconnect, any points of load connection under NER clause 4.8.9<br>• no load shedding is occurring or expected to occur anywhere on the power system under NER clause 4.8.9<br>• in AEMO's reasonable opinion the levels of short term and medium term capacity reserves available to the power system are at least equal to the required levels determined in accordance with the power system security and reliability standards. |
| Participant | An entity that participates in the national electricity market. |
| Plant capability | The maximum MW output which an item of electrical equipment |

| | |
|---|---|
| | is capable of achieving for a given period. |
| Power system reliability | The measure of the power system's ability to supply adequate power to satisfy demand, allowing for unplanned losses of generation capacity. |
| Power system security | The safe scheduling, operation and control of the power system on a continuous basis. |
| Reliable operating state | Refer to operating state. |
| Satisfactory operating state | Refer to operating state. |
| Secure operating state | Refer to operating state. |
| Separation event | In the context of frequency control ancillary services, this describes the electrical separation of one or more NEM regions from the others, thereby preventing frequency control ancillary services being transferred from one region to another. |
| Spot market | Wholesale trading in electricity is conducted as a spot market. The spot market allows instantaneous matching of supply against demand. The spot market trades from an electricity pool, and is effectively a set of rules and procedures (not a physical location) managed by AEMO (in conjunction with market participants and regulatory agencies) that are set out in the NER. |
| Supply-demand balance | A calculation of the reserve margin for a given set of demand conditions, which is used to minimise reserve deficits by making use of available interconnector capabilities. |
| Technical envelope | The power system's technical boundary limits for achieving and maintaining a secure operating state for a given demand and power system scenario. |
| Transmission network | The high-voltage transmission assets that transport electricity between generators and distribution networks. Transmission networks do not include connection assets, which form part of a transmission system. |
| Transmission network service provider (TNSP) | An entity that owns operates and/or controls a transmission network. |
| Unserved energy (USE) | The amount of energy that is required (or demanded) by consumers but which is not supplied due to a shortage of generation or interconnection capacity. Unserved energy does not include interruptions to consumer supply that are caused by outages of local transmission or distribution elements that do not significantly impact the ability to transfer power into a region. |

# A FREQUENCY OPERATING STANDARD

The *frequency operating standard* forms part of the *power system security standards*.

The Panel has determined to amend the *frequency operating standard*, in accordance with clause 8.8.3(a)(1) of the *Rules* with effect from 1 January 2020.

In this document:

- Section A.1 specifies the *frequency* bands for the purpose of *frequency operating standard* and the *Rules*.
- Section A.2 specifies the required **system frequency**outcomes following specified events.
- Section A.3 contains the definitions used in this document.

## A.1 Frequency bands

The *frequency* bands are shown in Table A.1.

For the purpose of the *frequency operating standard* and the *Rules,* a term in Column 1 means the *frequency* range in Column 3 for an **island**, Column 4 during **supply scarcity** in the mainland and Column 2 in all other conditions (**Normal**).

Table A.1: **Frequency bands**

| COLUMN 1 | COLUMN 2 | | COLUMN 3 | | COLUMN 4 |
|---|---|---|---|---|---|
| | NORMAL (HZ) | | ISLAND (HZ) | | SUPPLY SCARCITY (HZ) |
| | MAINLAND | TASMANIA | MAINLAND | TASMANIA | MAINLAND[1] |
| *normal operating frequency band* | 49.85 – 50.15 | | 49.5 – 50.5 | 49.0 – 51.0 | 49.5 – 50.5 |
| *normal operating frequency excursion band* | 49.75 – 50.25 | | 49.5 – 50.5 | 49.0 – 51.0 | 49.5 – 50.5 |
| *operational frequency tolerance band* | 49.0 – 51.0 | 48.0 – 52.0 | 49.0 – 51.0 | 48.0 – 52.0 | 48.0 – 52.0 |
| *extreme frequency excursion tolerance limit* | 47.0 – 52.0 | 47.0 – 55.0 | 47.0 – 52.0 | 47.0 – 55.0 | 47.0 – 52.0 |

Note: 1. The Reliability Panel has not determined separate *frequency* bands for periods of **supply scarcity** in Tasmania. Where a state of **supply scarcity** exists for the Tasmanian *power system*, the *frequency* bands set out in column 2 of table A.1 apply for an intact *power system*, and the *frequency* bands set out in column 3 of table A.1 apply for an **island** with the Tasmanian *power system*.

## A.2 Required frequency outcomes

The *power system* is expected to experience a range of different operating conditions. Tables A.2 — A.7 detail the required **system frequency** outcomes following the occurrence of the events specified in each Table.

**Table A.2: System frequency outcomes following specified conditions**

| | REQUIREMENT | MAINLAND | TASMANIA |
|---|---|---|---|
| 1 | **Accumulated time error** limit. | <15 seconds, except for an **island** or during **supply scarcity** | <15 seconds, except for an **island** or following a **multiple contingency event** |
| 2 | Except as a result of a *contingency event* or a **load event**, **system frequency**:<br>a) shall be maintained within the applicable normal operating frequency excursion band, and<br>b) shall not be outside of the applicable *normal operating frequency band* for more than 5 minutes on any occasion and not for more than 1% of the time over any 30-day period. | | |
| 3 | Following a **generation event** or a **load event, system frequency** shall be maintained within the applicable **generation and load change band**, and shall not be outside of the applicable *normal operating frequency band* for more than… | …5 minutes | …10 minutes |
| 4 | Following a **network event, system frequency** shall be maintained within the applicable *operational frequency tolerance band*, and shall not be outside of … | …the applicable **generation and load change band** for more than 1 minute, or be outside of the applicable *normal operating frequency band* for more than 5 minutes. | …the applicable *normal operating frequency band* for more than 10 minutes. |
| 5 | Following a **separation event, system frequency** shall be maintained within the applicable **island separation band,** and shall not be outside | **…generation and load change band** for more than 2 minutes, or be outside of the applicable *normal operating frequency band* for more than 10 minutes. | |

| | REQUIREMENT | MAINLAND | TASMANIA |
|---|---|---|---|
| | of the applicable… | | |
| 6 | Following a *protected event,* **system frequency** shall be maintained within the applicable extreme frequency excursion tolerance limit, and shall not be outside of the applicable **generation and load change band** for more than 2 minutes while there is no *contingency event,* or be outside of the applicable *normal operating frequency band* for more than 10 minutes while there is no *contingency event.* | | |
| 7 | Following a *non-credible contingency event* or **multiple contingency event** that is not a *protected event*, *AEMO* should use reasonable endeavours to:<br>(a) maintain **system frequency** within the applicable *extreme frequency excursion tolerance limits;* and<br>(b) avoid **system frequency** being outside of the applicable… | **…generation and load change band** for more than 2 minutes while there is no *contingency event,* or being outside of the applicable *normal operating frequency band* for more than 10 minutes while there is no *contingency event*. | |
| 8 | The size of the largest single **generation event** in the absence of a *transmission element outage* is limited to... | N/A | ...144 MW measured<br>a) at the *connection point* for a *generating system;*<br>b) at the *connection point* for one or more *generating systems* in an *identified user group* which share a *dedicated connection asset.*<br>This limit can be implemented in relation to any *generating system* with a capacity greater than 144 MW, or to one or more *generating systems* with a combined capacity greater than 144 MW which are *connected* to the *transmission network* by a *single* |

| | REQUIREMENT | MAINLAND | TASMANIA |
|---|---|---|---|
| | | | *dedicated connection asset,* by automatic *load shedding* or any other arrangements approved by *AEMO* that would effectively reduce any **generation event** in relation to the relevant *generating system(s)* to 144MW or below.[1] |

Note: 1. Under clause 4.8.9 of the *Rules, AEMO* may direct a *Generator* to exceed the 144 MW limit following a *contingency event* if *AEMO* reasonably believes this would be necessary to maintain a *reliable operating state*.

Table A.3: **Summary of mainland system frequency outcomes for an interconnected system**

| CONDITION | CONTAINMENT BAND (HZ) | STABILISATION BAND (HZ) | RECOVERY BAND (HZ) |
|---|---|---|---|
| No *contingency event* or **load event** | 49.75 – 50.25<br>49.85 – 50.15[1] | 49.85 – 50.15 within 5 minutes | |
| **Generation event** or **load event** | 49.5 – 50.5 | 49.85 – 50.15 within 5 minutes | |
| **Network event** | 49.0 – 51.0 | 49.5 – 50.5 within 1 minute | 49.85 – 50.15 within 5 minutes |
| **Separation event** | 49.0 – 51.0 | 49.5 – 50.5 within 2 minutes | 49.85 – 50.15 within 10 minutes |
| *Protected event* | 47.0 – 52.0 | 49.5 – 50.5 within 2 minutes | 49.85 – 50.15 within 10 minutes |
| **Multiple contingency event** | 47.0 – 52.0 (reasonable endeavours) | 49.5 – 50.5 within 2 minutes (reasonable endeavours) | 49.85 – 50.15 within 10 minutes (reasonable endeavours) |

Note: 1. 99% of the time.

Table A.4: **Summary of Mainland system frequency outcomes for an island within the Mainland other than during supply scarcity**

| CONDITION | CONTAINMENT BAND (HZ) | STABILISATION BAND (HZ) | RECOVERY BAND (HZ) |
|---|---|---|---|
| No *contingency event* or **load event** | 49.5 – 50.5 | N/A | |
| **Generation event**, **load event** or **network event** | 49.0 – 51.0 | 49.5 – 50.5 within 5 minutes | |
| The **separation event** that resulted in the **island** | 49.0 – 51.0[1] | 49.0 – 51.0 within 2 minutes | 49.5 – 50.5 within 10 minutes |
| *Protected event* | 47.0 – 52.0 | 49.0 – 51.0 within 2 minutes | 49.5 – 50.5 within 10 minutes |
| **Multiple contingency event** including a further **separation event** | 47.0 – 52.0 (reasonable endeavours) | 49.0 – 51.0 within 2 minutes (reasonable endeavours) | 49.5 – 50.5 within 10 minutes (reasonable endeavours) |

Note: 1. Or a wider band as notified to *AEMO* by a JSSC for a *region.*

Table A.5 applies in the **Mainland** during **supply scarcity** if:

1. Following a *contingency event*, the *frequency* has reached the **Recovery Band** set out in Table A.2.3, and *AEMO* considers the *power system* is sufficiently secure to begin *reconnection* of *load*.
2. The estimated *load* available for *under frequency schemes* within the **island** is more than the amount required to ensure that any subsequent *frequency* excursion would not go below the **Containment Band** and **Stabilisation Band** set out in Table A.5 as a result of a subsequent **generation event**, **load event**, **network event** or a **separation event** during *reconnection* of *load*.
3. The *generation reserve* available for *frequency* regulation is consistent with *AEMO's* current practice.

Table A.5: **Summary of Mainland system frequency outcomes during supply scarcity**

| CONDITION | CONTAINMENT BAND (HZ) | STABILISATION BAND (HZ) | RECOVERY BAND (HZ) |
|---|---|---|---|
| No *contingency event* or **load event** | 49.5 – 50.5 | N/A | |
| **Generation event**, **load event** or **network event** | Qld and SA: 48 – 52.0<br>NSW and Vic.:48.5 – 52.0[1] | 49.0 – 51.0 within 2 minutes | 49.5 – 50.5 within 10 minutes |
| *Protected event* | 47.0 – 52.0 | 49.0 – 51.0 within 2 minutes | 49.5 – 50.5 within 10 minutes |
| **Multiple contingency event** or **separation event** | 47.0 – 52.0 (reasonable endeavours) | 49.0 – 51.0 within 2 minutes (reasonable endeavours) | 49.5 – 50.5 within 10 minutes (reasonable endeavours) |

Note: 1. For the operation of an **island** that incorporates *power system* elements from more than one *region,* the Containment Band for a **generation event**, a **load event** or a **network event** is the narrower of the Containment Bands for the affected *regions*. For example, following a **generation event**, **load event** or **network event** during **supply scarcity** for an **island** that is partly within the Victoria *region* and partly within the South Australia *region,* the Containment band would be 48.5 – 52.0 Hz.

The frequency outcomes for Tasmania during supply scarcity are equivalent to the requirements set out in Table A.6 for an intact *power system* and in Table A.7 for an island within the Tasmanian *power system*.

Table A.6: **Summary of Tasmania system frequency outcomes where the Tasmanian power system is intact**

| CONDITION | CONTAINMENT BAND (HZ) | STABILISATION BAND (HZ) | RECOVERY BAND (HZ) |
|---|---|---|---|
| No *contingency event* or **load event** | 49.75 – 50.25<br>49.85 – 50.15[1] | 49.85 – 50.15 within 5 minutes | |
| **Generation event**, **load event** or **network event** | 48.0 – 52.0 | 49.85 – 50.15 within 10 minutes | |
| **Separation event** | 47.0 – 55.0 | 48.0 – 52.0 | 49.85 – 50.15 |

| CONDITION | CONTAINMENT BAND (HZ) | STABILISATION BAND (HZ) | RECOVERY BAND (HZ) |
|---|---|---|---|
| | | within 2 minutes | within 10 minutes |
| *Protected event* | 47.0 – 55.0 | 48.0 – 52.0<br>within 2 minutes | 49.85 – 50.15<br>within 10 minutes |
| **Multiple contingency event** | 47.0 – 55.0<br>(reasonable endeavours) | 48.0 – 52.0<br>within 2 minutes<br>(reasonable endeavours) | 49.85 – 50.15<br>within 10 minutes<br>(reasonable endeavours) |

Note: 1. 99% of the time.

Table A.7: **Summary of Tasmania system frequency outcomes where an island is formed within Tasmania**

| CONDITION | CONTAINMENT BAND (HZ) | STABILISATION BAND (HZ) | RECOVERY BAND (HZ) |
|---|---|---|---|
| No *contingency event* or **load event** | 49.0 – 51.0 | N/A | |
| **Load event, generation event or Network event** | 48.0 – 52.0 | 49.0 – 51.0 within 10 minutes | |
| **Separation event** | 47.0 – 55.0 | 48.0 – 52.0<br>within 2 minutes | 49.0 – 51.0<br>within 10 minutes |
| *Protected event* | 47.0 – 55.0 | 48.0 – 52.0<br>within 2 minutes | 49.0 – 51.0[1]<br>within 10 minutes |
| **Multiple contingency event** | 47.0 – 55.0 | 48.0 – 52.0<br>within 2 minutes<br>(reasonable endeavours) | 49.0 – 51.0<br>within 10 minutes |

Note: 1. In the FOS that came into effect on 14 November 2017, the Recovery band following a protected event for an island within Tasmania was incorrectly listed as 49.85 Hz — 50.15 Hz.

## A.3 Definitions

In this document:

- *Italicised* terms are defined in the National Electricity Rules.
- **Bold** terms are defined in table A.8.

Table A.8: Definitions

| TERM | DEFINITION |
|---|---|
| **accumulated time error** | For a measurement of **system frequency** that *AEMO* uses, the integral over time of the difference between 20 milliseconds and the inverse of that **system frequency**, starting from a time *published* by *AEMO*. |
| **generation and load change band** | For the **Mainland**:<br>1. 49.0 – 51.0 Hz for an **island**<br>2. during **supply scarcity**:<br>a. 48.0 – 52.0 in an island incorporating South Australia or Queensland; and<br>b. 48.5 – 52.0 in an island incorporating Victoria or New South Wales<br>3. 49.5 – 50.5 Hz otherwise.<br>For **Tasmania**: 48.0 – 52.0 Hz. |
| **generation event** | 1. a *synchronisation* of a *generating unit* of more than 50 MW;<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 no more than 30 seconds; or<br>3. the *disconnection* of *generation* as the result of a *credible contingency event* (not arising from a **load event**, a **network event**, a **separation event** or part of a **multiple contingency event**), in respect of either a single *generating system* or a single *dedicated connection asset* providing *connection* to one or more *generating systems.* |
| **island** | 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>1. does not include more than half of the combined *generation* of each of two *regions* (determined by available capacity before *disconnection*); and |

| TERM | DEFINITION |
|---|---|
| | 2. contains at least one whole *inertia sub-network*. |
| **island separation band** | For the **Mainland**:<br>1. for a part of the *power system* that is not an **island**, the *operational frequency tolerance band*;<br>2. for an **island** that includes a part of the *power system* to which no notice under paragraph (3) applies, the *operational frequency tolerance band*; and<br>3. 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 a **JSSC** to *AEMO* with adequate notice to apply to a nominated part of the **island** within the **JSSC's***region*.<br>For **Tasmania**: the *extreme frequency excursion tolerance limits.* |
| **JSSC** | *Jurisdictional System Security Coordinator* |
| **load event** | For the **Mainland**: *connection* or *disconnection* of more than 50 MW of *load* not resulting from a **network event**, **generation event**, **separation event** or part of a **multiple contingency event**.<br>For **Tasmania**: either a change of more than 20 MW of *load*, or a rapid change of flow by a *high voltage* direct current *interconnector* to or from 0 MW to start, stop or reverse its power flow, not arising from a **network event**, **generation event**, **separation event**or part of a **multiple contingency event**. |
| **multiple contingency event** | Either a *contingency event* other than a *credible contingency event,* a sequence of *credible contingency events* within 5 minutes, or a further **separation event** in an **island**. |
| **mainland** | The Queensland, New South Wales, Victoria and South Australia *regions*. |
| **network event** | A *credible contingency event* other than a **generation event, load event**, **separation event** or part of a**multiple contingency event**. |
| **separation event** | A *credible contingency event* affecting a *transmission element* that results in an **island**. |
| **supply scarcity** | Where *load* has been *disconnected* other than in accordance with *dispatch instructions* or a *direction* or *clause 4.8.9* |

| TERM | DEFINITION |
|---|---|
| | *instruction,* or the provision of a *market ancillary service,* and not yet restored. |
| **system frequency** | The *frequency* of the *power system,* or an **island** (as applicable). |
| **Tasmania** | The Tasmania *region*. |

# B SUMMARY OF STAKEHOLDER SUBMISSIONS

## B.1 Summary of stakeholder submissions to draft determination

Table B.1: **Summary of stakeholder submissions to the draft determination**

| STAKEHOLDER | ISSUE/COMMENT | RELIABILITY PANEL RESPONSE |
|---|---|---|
| **Dynamic Limit on Generation** | | |
| Woolnorth Holdings | Woolnorth propose that any limitation on generation to manage risk of credible contingencies should be a dynamic value based on actual raise services available at the time rather than a fixed generation limit to enable optimisation of the energy markets. | Noted. See section 4.1. |
| **Definition of a generation event in Tasmania** | | |
| TasNetworks | TasNetworks support the proposed changes to the limit of the size of the largest generation event in the Tasmanian power system, including the extension of the definition of a generation event to include the failure of a dedicated connection asset providing connection to one or more generating systems. TasNetworks intends to use the new definition and limit to appropriately manage future network connections.<br>TasNetworks notes that it does not intend to pursue retrospective application of the new FOS to Musselroe Wind Farm. | Noted. See section 4.1. |
| Meridian Energy | Meridian Energy consider that the Musselroe Wind Farm should be shielded from commercial impacts due to the proposed changes to the limit in the FOS for a generation event in the Tasmanian system. Meridian suggest that Musselroe Wind Farm be grandfathered the right to continue it operations as per the existing FOS. Meridian note that changing the FOS in a way that negatively impacts Musselroe Wind Farm is likely to have a subsequent negative impact on investment signals for future generation. Meridian propose that existing generation be exempted from the revised definition of a generation event and the application of the limit on the size of a generation event in Tasmania. | Noted. See section 4.1. |
| Australian Energy Council | The AEC propose that Musselroe Wind Farm be exempt from the retrospective application of the proposed changes to the limit on a generation event for the | Noted. See section 4.1. |

| STAKEHOLDER | ISSUE/COMMENT | RELIABILITY PANEL RESPONSE |
|---|---|---|
| | Tasmania power system, giving the following reasons:<br>• the generator investment was made in good faith under the previous definition<br>• the amount of exceedance of the maximum generation event is small - only 13 MW after allowing for losses and occurs infrequently<br>• the generator has been operating for 5 years under the existing definition with no obvious impact on the integrity of the Tasmanian network | |
| Hydro Tasmania | Hydro Tasmania support the proposed changes to the definition of a generation event to include the failure of a dedicated connection asset providing connection to one or more generating systems.<br>Hydro Tasmania support the application of the new definition and limit on the size of a generation event in Tasmania only for new connections to the Tasmanian power system.<br>Hydro Tasmania support the retention of the 144MW limit on the size of the largest generation event in the Tasmanian power system, noting that there may be challenges associated with the provision of the required quantity of R6 FCAS if the limit were raised to 155MW. In addition, new renewable generation will likely dilute the availability of synchronous generation needed to manage frequency disturbances, increasing the difficulty of maintaining system security in the Tasmanian power system. | Noted. See section 4.1. |
| Woolnorth Holdings | "Woolnorth does not support a retrospective application of the 144 MW limit being applied to Musselroe based on the in-service analysis of its performance and the frequency response to generator and network events since commissioning in 2013."<br>"Woolnorth contends that while the inclusion of the dedicated connection asset (DCA) to the assessment and definition of a generator event is appropriate for new connections the existing limit of 144 MW is not appropriate under all circumstances. This view is based | Noted. See section 4.1. |

| STAKEHOLDER | ISSUE/COMMENT | RELIABILITY PANEL RESPONSE |
|---|---|---|
| | on the historical performance of the wind farms, network responses, changes in the raise services availability and contributing factors around existing management of the FCAS requirement."<br><br>"A limit of 144 MW at the connection point represents up to 16 MW reduction to the peak metered generation capability. The estimated revenue loss has been calculated and coupled with costs associated with implementation of a [G*eneration Control Scheme and demonstrates that*] the future viability of the business is not sustainable."<br><br>"Musselroe [*Wind Farm*] was commissioned in 2013 with an installed capacity of 168 MW as measured at the generator terminals. A review of several contingency and market events demonstrates that the network, if appropriately configured, can cope with the loss of Musselroe during peak generation."<br><br>Woolnorth holdings note that Hydro Tasmania currently "manages the [*local*] FCAS requirement [*in Tasmania*] by remotely reducing generation at Musselroe and, at times, Bluff Point/Studland Bay to as low as 90 MW to meet the next largest generator requirements." This local control is not reflected in market dispatch or as an input to NEMDE.<br><br>Woolnorth holdings note there is a conflict between centralised (AEMO) control and local (Hydro Tasmania) control for the output of generation in Tasmania. Furthermore, Woolnorth note that: "The central and local duplication of managing the FCAS requirements is unlikely [to provide] a viable solution as the energy market in Tasmania continues to change over the coming years."Woolnorth holdings note there is a conflict between centralised (AEMO) control and local (Hydro Tasmania) control for the output of generation in Tasmania. Furthermore, Woolnorth note that: "The central and local duplication of managing the FCAS requirements is unlikely [to provide] a viable solution as the energy market in Tasmania continues to change | |

| STAKEHOLDER | ISSUE/COMMENT | RELIABILITY PANEL RESPONSE |
|---|---|---|
| | over the coming years."<br><br>"Woolnorth understands that it may be an option to regulate frequency requirement limits, but question [*if*] is this a blunt and simple solution to a more complex issue and one that risks stifling innovation and investment."<br><br>Woolnorth accept that sufficient frequency response will be required to maintain secure operation in the Tasmanian power system with increasing levels of renewable generation. However, it points out that there are a number of developments that are bringing additional FCAS supply to the Tasmanian market including:<br><br>• 108MW of fast raise FCAS via Hydro Tasmania's Adaptive Under Frequency Load Shedding Scheme (AUFLS), commisioned in 2018.<br><br>• Musselroe is in the process of testing its ability to provide Regulation and Contingency raise and lower services.<br><br>Woolnorth suggest that the application of a regulatory limit on the operation of wind farms in Tasmania may conflict with the National Electricity Objective in relation to efficient long term investment of generation in Tasmania. Woolnorth suggest that the Panel's 2008 determination to place a limit on the size of a generation event in Tasmania be reconsidered in light of changes to the FCAS situation in Tasmania due to Basslink contribution, the new and existing Hydro Tasmania services and the FCAS trial being undertaken at Musselroe.<br><br>"Woolnorth suggests that the generator event contingency size should be measured and calculated based on the actual MW contribution to the network requirements. This can be determined by the Regional reference node contribution." | |
| **Generation and load change band** | | |
| Energy | Energy Queensland support the Panel's draft | Noted. See |

| STAKEHOLDER | ISSUE/COMMENT | RELIABILITY PANEL RESPONSE |
|---|---|---|
| Queensland | determination to maintain the existing settings in the FOS in relation to contingency events. | section 4.2. |
| TasNetworks | TasNetworks supports the retention of the existing settings in the FOS that relate to the management of credible contingency events. | Noted. See section 4.2. |
| Australian Energy Council | The AEC support the retention of the exiting settings in the FOS in relation to the management of credible contingency events. | Noted. See section 4.2. |
| **Considerations of the accumulated time error** | | |
| Australian Energy Council | The AEC note that accumulated time error is a useful metric for monitoring the frequency performance of the power system and the energy market. The AEC suggest that the accumulated time error limit be re-expressed such that a rapid change triggers an investigative action but does not oblige AEMO to reduce it through intentional frequency biases in future, unrelated dispatch intervals. | Noted. See section 4.3. |
| **FOS document structure** | | |
| TasNetworks | TasNetworks consider that the structure and formatting of the revised document is likely to help stakeholders understand the specific frequency control requirements for the Tasmanian region. | Noted. See section 4.4. |
| Delta Electricity | Delta suggest a range of clarifications to the wording of specific elements of the FOS to avoid misinterpretation. | Noted. See section 4.4. |
| **Frequency bands defined by the FOS** | | |
| Delta Electricity | Assessment of frequency bands in the FOS should include consideration of the technical impacts of frequency variations on electrical machinery connected to the power system. Delta suggest that the NOFB be set such that controllers that are not designed to control frequency do not detect changes to their control parameters caused by frequency changes within the NOFB. | Outside the scope of this review.<br>Noted for further consideration throughout the ongoing Frequency Control Work Program.<br>See section 3.2. |

| STAKEHOLDER | ISSUE/COMMENT | RELIABILITY PANEL RESPONSE |
|---|---|---|
| Australian Energy Council | The Energy Council note that the consideration of the NOFB is a pressing concern in relation to dealing with the current frequency control challenges in the NEM. "...in the AEC's view, it is the role of the Panel to firstly set the desired outcome and it is then the role of the solution workstreams to find the most efficient solutions to deliver that outcome." | Noted for further consideration throughout the ongoing Frequency Control Work Program.<br>See section 3.2. |
| **General comments on the FOS and future reviews** | | |
| Delta Electricity | Noting the impact of rooftop PV during the power system events of 25 August 2018, Delta suggest that a future iteration of the FOS may consider the system security risk posed by poor coordination of limits in the FOS and within inverters in rooftop PV systems.<br>The FOS may benefit from further review following completion of AEMO's current review of the MASS. | Noted. |
| TasNetworks | TasNetworks note that in the medium term there is a chance that the AETV power station may be permanently decommissioned and at such time a further review of the Frequency operating standards for Tasmania may be appropriate. | Noted. |
| Hydro Tasmania | Hydro Tasmania note that there are projects planned over the medium to longer term that are likely to significantly alter the operation of the Tasmanian power system such as the Battery of the Nation and Project Marinus. Hydro Tasmania suggest the Panel consider triggering a review of the FOS if, at some stage in the future, a final investment decision is made on either of these projects. | Noted. |
| Meridian Energy | Meridian Energy is generally supportive of the Panels draft FOS. | Noted. |

# C TERMS OF REFERENCE FOR THE REVIEW

**Revised — 26 July 2018**

**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.

**The Panel's role and responsibility in relation to theFOS**: 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.

**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 time frames 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 includes 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 settings in the frequency operating standard for Tasmania were last reviewed and determined by the Reliability Panel on 18 December 2008. The settings in the frequency operating standard for the mainland were last reviewed and determined by the Reliability Panel on 16 April 2009.

On 14 November 2017, the panel published a final determination for stage one of the review of the FOS. This determination included a revised FOS for Tasmania and the mainland which addressed the following issues:

- the inclusion of a standard for protected events in alignment with the *Emergency frequency control schemes* rule change published on 30 March 2017
- clarification of the FOS in relation to multiple contingency events
- revision of the definitions in the FOS in relation to island operation and generation events
- revision of the limit on accumulated time error that applies in the mainland.

This revised terms of reference relates to the completion of stage two of the review of the FOS.

**Revised scope for stage two 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 outcomes from the AEMO and AEMC projects and investigations set out in the ongoing frequency control work plan, published as part of the final report for the AEMC's *Frequency Control Frameworks Review*.

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, including:
  - the settings of the frequency bands and time requirements for maintenance and restoration of system frequency
  - the thresholds that apply for load and generation events
  - the limit in the FOS on accumulated time error.
- improvements to the structure and consistency of the FOS document
- other issues related to the FOS as determined by the Panel.

The Panel's review of the FOS must consider and determine the 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.

**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 ten 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 March 2019.[67]

67 On 25 August 2019, the AEMC extended the completion date for the Review of the frequency operating standard from 31 March 2019 to 30 April 2019.