Australian Energy Market Commission

AEMC Reliability Panel

Application of Frequency Operating Standards During Periods of Supply Scarcity

Draft Determination

September 2008

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About the AEMC

The Council of Australian Governments, through its Ministerial Council on Energy, established the Australian Energy Market Commission (AEMC) in July 2005 to be the Rule maker for national energy markets. The AEMC is currently responsible for Rules and policy advice covering the National Electricity Market. It is a statutory authority. Our key responsibilities are to consider Rule change proposals, conduct energy market reviews and provide policy advice to the Ministerial Council as requested, or on AEMC initiative.

About the AEMC Reliability Panel

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

Disclaimer

The views and recommendations set out in this document are those of the Reliability Panel and are not necessarily those of the Australian Energy Market Commission.

Reliability Panel Members

Chairman

Ian C Woodward, Commissioner, Australian Energy Market Commission

Other AEMC Reliability Panel Members

Kerry Connors, former Executive Officer, Consumer Utilities Advocacy Centre

Jeff Dimery, General Manager, Merchant Power, AGL Energy

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Les Hosking, Managing Director and CEO, NEMMCO

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Stephen Orr, Commercial Director, International Power Australia

David Swift, Chief Executive, Electricity Supply Industry Planning Council

Geoff Willis, former CEO, Hydro Tasmania

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Abbreviations

Italicised terms in this report have the same meaning as in Chapter 10 of the National Electricity Rules.

AEMC	Australian Energy Market Commission
AER	Australian Energy Regulator
Commission	see AEMC
FCAS	Frequency Control Ancillary Services (Market Ancillary Services in the Rules)
MCE	Ministerial Council on Energy
NECA	National Electricity Code Administrator
NEL	National Electricity Law
NEM	National Electricity Market
NEMMCO	National Electricity Market Management Company
NEO	National Electricity Objective
Panel	Reliability Panel
Rules	National Electricity Rules
TNSP	Transmission Network Service Provider
UFLS	Under frequency load shedding
UFLSS	Under frequency load shedding scheme

Executive Summary

This document presents the Draft Determination of the Australian Energy Market Commission (AEMC) Reliability Panel (Panel) in relation to the mainland *frequency operating standards* in the National Electricity Market (NEM) during periods of supply scarcity. The NEM mainland *frequency operating standards* define the range of allowable frequencies for the power system while the load is being restored following a major power system incident on the NEM mainland.

The Australian Energy Regulator (AER) identified a need for this review following its review of the incident in Victoria on 16 January 2007 when a large portion of load was shed based on the Under Frequency Load Shedding Scheme (UFLSS). The AER recommended that National Electricity Market Management Company (NEMMCO) should seek clarification on whether the lower limit of the NEM mainland *frequency operating standards* for a single contingency could be reduced to 47.5 Hz during periods of supply scarcity associated with load restoration. NEMMCO's request to the Panel included analysis of the impact of the proposal.

Following stakeholder's submissions, NEMMCO made further recommendations on the changes of the *frequency operating standards*. Those recommendations were to mitigate the associated risks and provide clarification.

These further recommendations differ from NEMMCO's original proposal in that:

- the lower frequency level is changed from 47.5 to 48 Hz to reduce the risk that performance of some generating units may be conducted as borderline;
- the contingency reserve requirements apply to network events in addition to generator events;
- an upper frequency of 52 Hz is proposed for load and network events;
- stabilisation and recovery frequency ranges and response times are specified; and
- the preconditions for reducing the FCAS requirements during load restoration are specified.

The Panel must have regard to the national electricity objective (NEO)[1], which is set out in section 7 of the National Electricity Law (NEL), when it performs this review of the NEM mainland *frequency operating standards*.

The Panel considers that NEMMCO's modified proposal is likely to contribute to the NEO because:

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1 "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—
(a) price, quality, safety, reliability and security of supply of electricity; and
(b) the reliability, safety and security of the national electricity system."

- the amended NEM mainland *frequency operating standards* will enable the loss of supply to be restored in a shorter period of time; and

- the increased risks of amending the mainland *frequency operating standards* will likely be marginal and manageable, and mitigation of the risks has been taken into account by the NEMMCO.

Therefore, the Panel has decided to adopt NEMMCO's recommended changes to the NEM mainland *frequency operating standards* during periods of supply scarcity. The proposed amendments to the standards are included in Appendix A.

Initially the AEMC's terms of reference for this review allowed for only one round of consultation. However, as stakeholders have not had the opportunity to comment on NEMMCO's modified proposal, the Panel requested the AEMC amend the terms of reference to allow publication of this Draft Determination and an additional round of consultation.

Completion of this review

The completion of this review will follow the indicative timetable below:

Submissions on Draft Determination close	Friday 24 October 2008
Submit Final Determination to the AEMC	By Friday 19 December 2008

Submissions on this Draft Determination

Interested stakeholders are invited to provide comments on the Draft Determination outlined in this Paper. Submissions should be received by 5 pm on Friday 24 October 2008.

Submissions may be sent electronically to submissions@aemc.gov.au or by mail to:

Australian Energy Market Commission
PO Box A2449
Sydney South NSW 1235

or by Fax: (02) 8296 7899.

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1 Context of the Review

1.1 The existing NEM mainland Frequency Operating Standards

In September 2001, National Electricity Code Administrator Limited (NECA) published the mainland *frequency operating standards*[1] in the National Electricity Market (NEM). These *frequency operating standards* were determined by the NECA Reliability Panel through consultation with stakeholders.

The purpose of the NEM mainland *frequency operating standards* is to define the range of allowable frequencies for the electricity power system under different conditions, including normal operation and following contingencies. Generator, network and end-user equipment must be capable of operating within the range of frequencies defined by the *frequency operating standards*, while NEMMCO is responsible for maintaining the frequency within the ranges defined by these standards.

1.2 NEMMCO's request for clarification of the NEM mainland Frequency Operating Standards during periods of supply scarcity

1.2.1 Load restoration following the power system incident on 16 January 2007 in Victoria

On 16 January 2007, a major power system incident occurred on the interconnected power system during a bushfire in northern Victoria. During the incident, the Victorian region was islanded from the remainder of NEM mainland and approximately a quarter of the load was shed by the Under Frequency Load Shedding Scheme (UFLSS). It took several hours to restore the load after the event. The rate at which the shed load could be reconnected following the incident was limited by the requirement on NEMMCO to maintain sufficient contingency reserves to cover the loss of the largest unit in the Victorian electrical island without the need for further Under Frequency Load Shedding (UFLS).

On 6 November 2007, the Panel received a request from NEMMCO seeking clarification of the application of NEM mainland *frequency operating standard* during periods of supply scarcity. This request arose from the AER's investigation into the incident on 16 January 2007.

The AER investigated the events on 16 January 2007 and published its investigation report[2]. Recommendation 12 of the AER's report was that "NEMMCO should seek

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1 For detailed information, refer to the NEM mainland *frequency operating standards,* available at: http://www.neca.com.au/Files/RP_Final_Determination_Sep_2001.pdf. The standards are also available on the AEMC website at http://www.aemc.gov.au/electricity.php?r=20080226.172500.

2 AER, September 2007, *The events of 16 January 2007 Investigation Report*, available at: http://www.aer.gov.au/content/index.phtml/itemId/714828

clarification from the Reliability Panel as to whether it is intended, under the *frequency operating standards*, for sufficient generation to be held in reserve to cover the loss of a generating unit during periods of load restoration following a contingency event".[3]

1.2.2 NEMMCO's alternative approach to restoring load

NEMMCO recommended that only sufficient contingency reserves should be retained to prevent the frequency dropping to 47.5 Hz following the loss of the largest generating unit in the affected region, rather than the existing requirement of 49.5 Hz for an intact system or 49.0 Hz for an island system. It suggested that retaining less contingency reserves would allow NEMMCO to restore the load shed during the power system incident at a greater rate.

NEMMCO suggested that 47.5 Hz should be chosen because if the frequency falls below 47.5 Hz which is outside the frequency operating range of the UFLS, there would be a number of generating units in the NEM mainland that would be likely to trip.

For Tasmania, NEMMCO did not recommend a change to the current practice because it considered that, using the alternative approach, the risk of a cascading system failure may be significantly greater due to the lower frequencies likely to be reached.[4]

1.3 Terms of Reference (ToR) for the review

1.3.1 Original ToR

On 18 March 2008, the AEMC provided the ToR to the Panel. The AEMC requested that the Panel, in accordance with section 38 of the NEL and clause 8.8.3 of the National Electricity Rules (NER), undertakes a review of the NEM mainland *frequency operating standards* with respect to the level of generation held in reserve while restoring load in the NEM mainland during periods of supply scarcity.

The Tasmanian *frequency operating standards* are excluded from the scope of this particular review as NEMMCO does not proposed a change to the operation of the *frequency operating standards* for Tasmania.

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3 NEMMCO, 20 February, 2008, *Progress on recommendations from power system incident report on 16 January 2007 event,* page 6, available at: http://www.nemmco.com.au/marketandsystemevents/232-0076.htm

4 The Panel is currently reviewing the Tasmanian *frequency operating standards* and further information is available at http://www.aemc.gov.au/electricity.php?r=20080828.163451.

1.3.2 Amended ToR

The Panel consulted on NEMMCO's proposal and received submissions from Powerlink, the ERAA and the NGF. In addition the Panel had a concern regarding the criteria for when the proposed amendments to the *frequency operating standards* would apply.

The Panel, in consultation with NEMMCO, is proposing amendments to NEMMCO's original proposal. The Panel considers that these amendments are sufficiently material that stakeholders should be given an opportunity to consider them prior to the Panel preparing its Final Determination.

On 19 June 2008 the AEMC approved an amendment to the ToR that allows the Panel to consult on a Draft Determination for this review, rather than proceeding directly to a Final Determination, as required by the original terms of reference. This amendment to the ToR did not change the requirement on the Panel to complete the review by the end of this year.

1.4 Assessment criteria

The Panel must have regard to the national electricity objective (NEO)[5] when it performs this review of the NEM mainland *frequency operating standards*. The NEO is:

> "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—
>
> (a) price, quality, safety, reliability and security of supply of electricity; and
>
> (b) the reliability, safety and security of the national electricity system."

5 The national electricity objective is which is set out in section 7 of the NEL.

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2 Assessment of NEMMCO's proposal

2.1 NEMMCO's proposal

NEMMCO's proposal includes a detailed risk analysis of NEMMCO's alternative approach. NEMMCO considered that the alternative approach is more efficient in restoring load during loss of supply events with acceptable increase in risks.

NEMMCO stated two reasons that it considered the increased risks of the alternative approach to be relatively small:

- the relatively low probability of such a credible contingency event during load restoration (probably no more than 5% even if load restoration were to take 6 hours); and
- the design of the generator technical performance standards[6].

NEMMCO considered that the risks for Tasmania, using the alternative approach, of a cascading system failure may be significantly greater due to the lower frequencies likely to be reached, and did not recommend any change to the current practice.

2.2 Stakeholder views

The Panel received submissions from Powerlink, Energy Retailers Association of Australia (ERAA) and National Generators Forum (NGF).

All three submissions agreed, in principal, that during load restoration or scarcity of supply events the NEM mainland Frequency Operating Standards could be relaxed to restore electricity supply to customers as soon as possible. However, the ERAA and the NGF expressed concerns about NEMMCO's recommendation. Those concerns are summarised below.

2.2.1 Greater analysis of risks and implications of the recommended approach.

The ERAA considered that the benefits of more rapidly reconnecting customers should outweigh the minor increase in risk posed by NEMMCO's recommended approach. However, it noted that NEMMCO's analysis is fairly high level. It suggested that greater analysis into the potential risks and implications of the recommended approach should be provided to ensure that the approach is acceptable.

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6 NEMMCO, 6 November 2008, *Application of Frequency Operating Standard during Periods of Supply Scarcity,* page 2, available at: http://www.aemc.gov.au/electricity.php?r=20080327.122851

2.2.2 Linkage to Under Frequency Load Shedding (UFLS) Setting Review.

The NGF noted that there is currently an UFLS review being conducted confidentially by a joint jurisdictional planning body committee. The NGF considered it necessary for the Panel and participants to be informed and consulted in relation to that UFLS review before NEMMCO's proposal was considered.

2.2.3 Interaction with Generator technical performance standards.

The NGF indicated its concerns that 47.5 Hz was chosen as the lower limit of the *operational frequency tolerance band* that applies during periods of load restoration because it considered some generators may have a grandfathered registered performance standard that allows their generating units to trip above this frequency. The NGF suggested that the *operational frequency tolerance band* that applies during periods of load restoration should not be lower than any large generators operating frequency limit as registered in its performance standard.

2.2.4 Risks of targeting a "borderline" Frequency.

Similarly, the NGF suggested that it would be risky to set the *operational frequency tolerance band* that applies during periods of load restoration at the borderline of the relevant performance standards. Therefore, the NGF proposed that a level of "safety margin" should be considered somewhere between the current practice and the alternative approach.

2.3 Panel's concern – preconditions for proposed standard

The Panel also considers that before NEMMCO reduces the Frequency Control Ancillary Services (FCAS) requirements during load restoration it should wait until the power system was fully stable, including all remaining generating units operating in a stable manner and the impact of the incident known.

2.4 NEMMCO's views on stakeholder and Panel views

NEMMCO subsequently took stakeholder submissions and the Panel's concern into consideration and proposed amendments to the original proposal. These amendments differ from NEMMCO's original proposal in that:

- the lower frequency level is changed from 47.5 to 48 Hz to reduce the risk that performance of some generating units may be conducted as borderline;
- the contingency reserve requirements apply to network events in addition to generator events;
- an upper frequency of 52 Hz is proposed for load and network events;
- stabilisation and recovery frequency ranges and response times are specified; and

- the preconditions for reducing the FCAS requirements during load restoration are specified.

2.4.1 Jurisdictional review of under frequency load shedding

NEMMCO advised the Panel that the re-designed UFLSS was approved by the jurisdictional planning bodies and work has commenced on its implementation, which is scheduled for completion in 2009.[7]

NEMMCO also advised that the modified UFLSS will continue to operate within the frequency range of 47.5 to 49.0 Hz and that the changes related to re-arranging the load blocks and settings to better suit the nature of the NEM power system. Therefore, NEMMCO does not consider that there is a dependency between the UFLS review and this Panel review.

The Panel agrees with NEMMCO because the changes to the UFLSS appear unlikely to affect the overall system performance during periods of low frequency.

2.4.2 Raising the lower limit of the single contingency event band to 48 Hz

Raising the lower frequency limit from 47.5 Hz to 48 Hz reduces the probability of a cascading failure because it:

- does not expose generating units to a frequency a low as 47.5 Hz, in particular generating units that have a grandfathered performance standard that allows them to trip at or above this frequency; and

- provides a safety margin of 0.5 Hz between the lowest expected frequency following a single contingency during a period of load restoration and the bottom of the UFLS operating range.

However, raising this frequency to 48 Hz does require more FCAS and will therefore reduce the rate at which NEMMCO can restore load following a significant multiple contingency. NEMMCO advised the Panel that the impact on the rate at which load is restored depends on the size of the initial contingency event. If the minimum frequency following the contingency event is:

- well above 48 Hz then there should not be an issue as there should be enough load left connected on UFLS at settings above 48 Hz to be able to handle loss of the largest unit whilst keeping the frequency above 48 Hz; while

- closer to or below 48 Hz then NEMMCO would not be able to rely solely on UFLS to cover loss of the largest generating unit.

[7] The guiding principles for this review were set by the MCE and are available at: http://www.mce.gov.au/assets/documents/mceinternet/FINALMCEStatementonUFLSP20041222181846.pdf

Thus for smaller events the proposed change would have no impact but for larger events it could well reduce the rate of restoration of load. Appendix B provides a more detailed description of the effect of the contingency size on the rate at which NEMMCO can restore load.

2.4.3 Clarification of settings

NEMMCO advised that its proposal should:

- apply to network events as well as generator events if the benefits of reduced FCAS requirements are to be fully captured;
- adopt the same normal frequency ranges as those that apply to an island because of the difficulty in finely controlling the frequency during both island and load restoration conditions bands; and
- adopt the same stabilisation and recovery times and associated frequency ranges should be the same as those that apply within an island.

2.4.4 Preconditions for reduced FCAS requirements during load restoration

NEMMCO advised that immediately following a significant system incident the first action is to ensure that the frequency recovers as required by the frequency operating standard. At this point there is no guarantee that there would be enough FCAS available to cover the loss of the largest generating unit. In some cases all generating units will be operating close to their maximum and the only way to achieve sufficient FCAS may be manual load shedding while lowering the output of generating units to allow the FCAS to be provided. Thus there might be a situation where NEMMCO is initially required to shed further load to ensure the FCAS is available and then shortly afterwards, when the time is reached that the new provisions can apply, NEMMCO would restore this load and then proceed with further load restoration where possible. NEMMCO considers that it may be difficult to explain to some stakeholders why this load shedding was necessary.

NEMMCO advised the Panel of a possible alternative where reducing FCAS requirements would not be implemented until the power system was in a satisfactory operating state. This requires that the conditions of the power system be stable. Following the initial contingency, and after the power system has been brought to a satisfactory operating state, NEMMCO would be aiming to achieve a Secure Operating State within 30 minutes.

NEMMCO advised the Panel that it considers that the alternative of requiring the NEM to be in a secure operating state is preferable and easier to explain, and also gives NEMMCO flexibility should unforseen circumstances arise. To be more conservative NEMMCO would wait until the system is secure before reducing the FCAS requirements, noting that during the periods of reduced FCAS the system would remain secure (in the absence of a subsequent contingency) as associated wider allowable frequency band would be within the part of the *frequency operating standards* that apply during load restoration.

2.5 Amended NEMMCO recommendation

The following table summarises NEMMCO's proposed changes to the NEM mainland *frequency operating standards* that would apply during supply scarcity, including for an island.

Condition	Containment	Stabilisation	Recovery
Generation event, load event, network event or separation event during load restoration following a contingency event. This provision is subject to specific requirements in notes 1 to 3 below.	48 to 52 Hz	49 to 51 Hz within 2 minutes	49.5 to 50.5 Hz within 10 minutes

Notes for periods of supply scarcity during load restoration:

1. The power system has undergone a contingency event, the frequency has reached the Recovery frequency band and NEMMCO considers the power system is sufficiently stable to begin load restoration.

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

3. Pre-determined amount of generation reserve is available for frequency regulation.

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3 Draft Determination

The Panel has published this Draft Determination in accordance with the amended ToR from the Panel. This allows stakeholders further opportunity to consider the amendments to NEMMCO's original proposal prior to the Panel making its Final Determination.

3.1 Assessment of the Proposal

In making its determination, the Panel considered the amended NEMMCO proposal against the NEO, in particular:

- the benefits of the proposal to end use customers; and
- any increased system security and reliability risks.

3.1.1 Benefits to customers

The Panel considers that relaxing the FCAS requirements during a load restoration period will make more generator capacity available to supply customers. This is expected to allow NEMMCO to restore supply at a faster rate, thus reducing the impact on customers following a significant multiple contingency event.

The Panel's view is consistent with NEMMCO's proposal and the views expressed in all the submissions.

3.1.2 System security and reliability risks

Under NEMMCO's proposal, during a period of load restoration it would, when conditions were suitable, only procure sufficient FCAS to limit the drop of the NEM mainland frequency following a contingency to 48 Hz (originally proposed to be 47.5 Hz). Allowing the frequency to drop this low would mean that:

- further load may be shed on under frequency as the UFLSS operates between 49 Hz and 47.5 Hz; and
- the remaining generating units would be exposed to this lower frequency, potentially increasing the probability that these generating units would trip and result in a cascading system blackout.

NEMMCO considers that the risk of further load shedding is relatively low. It estimates that the probability of a credible generator contingency event occurring during a period of load restoration at about 5%[8]. Also, allowing the frequency to drop to 48 Hz, instead of the originally proposed 47.5 Hz will also reduce the quantity of load that would be shed on under frequency should a contingency occur.

8 See page 9 of the NEMMCO proposal dated 6 November 2007.

The Panel considers that the risk of further generating units tripping on under frequency is low as the minimum access standards require generating units to be able to operate down to 47 Hz on the mainland. However, as discussed in chapter 2, some generating units may have grandfathered performance standards that mean they may be at an increased risk of tripping at 47.5 Hz, so the proposal has been amended to limit the drop in frequency to 48 Hz. The Panel, after consultation with NEMMCO, believes the risk of generating units tripping at 48 Hz is not material.

3.2 Draft determination

Overall, the Panel considers that the benefits of relaxing NEM mainland *frequency operating standards* during periods of supply scarcity outweigh the marginal increase in power security risk, particular as this risk is mitigated by amending NEMMCO's proposal to only allow the frequency to drop to 48 Hz following a single contingency.

Therefore, the Panel considers that NEMMCO's proposal, as amended and presented in Appendix A, is likely to advance the NEO.

A Draft NEM Mainland frequency operating standards

The Panel is proposing to amend, in accordance with clause 8.8.3 of the Rules and section 38 of the NEL, the NEM Mainland *frequency operating standards* to those contained in this Appendix.

Part A Summary of the Standards

The NEM Mainland *frequency operating standards* set out in Part B are summarised in the following tables for convenience. To the extent of any inconsistency between these tables and Part B below, Part B prevails.

The following table applies to any part of the NEM Mainland *power system*, other than an *island* or during periods of supply scarcity during load restoration:

Draft NEM Mainland Frequency Operating Standards – interconnected system

Condition	Containment	Stabilisation	Recovery
Accumulated time error	5 seconds		
no *contingency event* or *load event*	49.75 to 50.25 Hz, 49.85 to 50.15 Hz 99% of the time	49.85 to 50.15 Hz within 5 minutes	
generation event or *load event*	49.5 to 50.5 Hz	49.85 to 50.15 Hz within 5 minutes	
network event	49 to 51 Hz	49.5 to 50.5 Hz within 1 minute	49.85 to 50.15 Hz within 5 minutes
separation event	49 to 51 Hz	49.5 to 50.5 Hz within 2 minutes	49.85 to 50.15 Hz within 10 minutes
multiple contingency event	47 to 52 Hz	49.5 to 50.5 Hz within 2 minutes	49.85 to 50.15 Hz within 10 minutes

Draft NEM Mainland Frequency Operating Standards – island system

Condition	Containment	Stabilisation	Recovery
no *contingency event, or load event*	49.5 to 50.5 Hz		
generation event, load event or *network event*	49 to 51 Hz	49.5 to 50.5 Hz within 5 minutes	
the *separation event* that formed the *island*	49 to 51 Hz or a wider band notified to NEMMCO by a relevant Jurisdictional Coordinator	49.0 to 51.0 Hz within 2 minutes	49.5 to 50.5 Hz within 10 minutes
multiple contingency event including a further *separation event*	47 to 52 Hz	49.0 to 51.0 Hz within 2 minutes	49.5 to 50.5 Hz within 10 minutes

Draft NEM Mainland Frequency Operating Standards – during supply scarcity

Condition	Containment	Stabilisation	Recovery
no *contingency event* or *load event*	49.5 to 50.5 Hz		
generation event, load event or *network event* Refer to notes below for specific requirements to be satisfied prior to use this provision.	48 to 52 Hz	49 to 51 Hz within 2 minutes	49.5 to 50.5 Hz within 10 minutes
multiple contingency event or separation event	47 to 52 Hz	49.0 to 51.0 Hz within 2 minutes	49.5 to 50.5 Hz within 10 minutes

Notes for periods of supply scarcity during load restoration:

1. The power system has undergone a contingency event, the frequency has reached the Recovery frequency band and NEMMCO considers the power system is sufficiently stable to begin load restoration.

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

3. Pre-determined amount of generation reserve is available for frequency regulation.

Part B The Frequency Operating Standards

For the purposes of Chapter 4, 5 and 10 of the Rules, the *frequency operating standards*, forming part of the power system security and reliability standards, are:

(a) except in an island or during load restoration, the accumulated time error should not exceed 5 seconds;

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

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

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

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

(f) as a result of any multiple contingency event, system frequency should not exceed the *extreme frequency excursion tolerance limit*s and should not exceed the applicable generation and load change band for more than two minutes while there is no contingency event or exceed the applicable *normal operating frequency band* for more than ten minutes while there is no contingency event.

Part C Application of Rules Terms

For the purposes of these frequency operating standards and Chapters 4, 5 and 10 of the Rules, a term shown in Column 1 of the following table has the corresponding range shown in Column 3 of the table for an island and has the corresponding range shown in Column 2 of the table otherwise.

Draft Tasmanian Frequency Operating Standards – Rule terms

Column 1	Column 2	Column 3	Column 4
Term	**Normal range (Hz)**	**Island range (Hz)**	**Restoration range (Hz)**
normal operating frequency band	49.85 to 50.15	49.5 to 50.5	49.5 to 50.5
normal operating frequency excursion band	49.75 to 50.25	49.5 to 50.5	49.5 to 50.5
operational frequency tolerance band	49.0 to 51.0	49.0 to 51.0	48.0 to 52.0
extreme frequency excursion tolerance limit	47.0 to 52.0	47.0 to 52.0	47.0 to 55.0

PART D DEFINITIONS

Words and phrases shown in Italics in this document have the meaning given to them in the following table:

Term	Meaning
abnormal frequency island	means a part of the power system that includes generation, networks and *load for which all of its alternating current network connections with* other parts of the power system have been disconnected, provided that the part does not include more than half of the generation of each of two *regions (determined by available capacity before disconnection).*
accumulated time error	means, in respect of a measurement of *system frequency* that NEMMCO uses for controlling *system frequency*, the integral over time of the difference between 20 milliseconds and the inverse of that *system frequency*, starting from a time *published* by *NEMMCO.*
available capacity	has the meaning given to it in the Rules.
connection point	has the meaning given to it in the Rules.
contingency event	has the meaning given to it in the Rules.
credible contingency event	has the meaning given to it in the Rules.
electrical island	means a part of the *power system* that includes *generation*, *networks and load*, for which all of its network connections with other parts of the *power system* have been disconnected, provided that the part does not include more than half of the *generation* of each of two regions (determined by available capacity before disconnection).
extreme frequency excursion tolerance limits	has the meaning given to it in the Rules.
frequency operating standards	has the meaning given to it in the Rules and are the standards set out in Part B of this document.
generating unit	has the meaning given to it in the Rules.
generation	has the meaning given to it in the Rules.

Term	Meaning
generation and load change band	means the frequency range of 49.0 to 51.0 Hz in respect of an island and the frequency range of 49.5 to 50.5 Hz otherwise .
generation event	means a *synchronisation* of a *generating unit* of more than 50 MW or a *credible contingency event* in relation to a single generating unit, not arising from a *network event*, a *separation event* or a part of a *multiple contingency event*.
island	means either an *electrical island* or an *abnormal frequency island*.
island separation band	means: (a) in respect of a part of the *power system* that is not an island, the *operational frequency tolerance band;* (b) in respect of an *island* that includes a part of the power system to which no notice under paragraph (c) applies, the *operational frequency tolerance band;* and (c) otherwise in respect of an *island*, the frequency band determined by the most restrictive of the high limits and low limits of frequency ranges outside the *operational frequency tolerance band* notified by *Jurisdictional Coordinators* to *NEMMCO* with adequate notice to apply to a nominated part of the *island* within their respective jurisdictions.
Jurisdictional Coordinator	has the meaning given to it in the Rules.
load	has the meaning given to it in the Rules.
load event	means an identifiable connection or disconnection of more than 50 MW of customer load (whether at a *connection point* or otherwise), not arising from a *network event, a generation event, a separation event* or a part of a *multiple contingency event*.
multiple contingency event	means either a *contingency event* other than a *credible contingency event*, a sequence of *credible contingency events* within a period of 5 minutes, or a further *separation event in an island*.
NEMMCO	has the meaning given to it in the Rules.
network	has the meaning given to it in the Rules.
network event	means a *credible contingency event* other than a *generation event*, a *separation event* or a part of a *multiple contingency event*.
normal operating frequency band	has the meaning given to it in the Rules.
normal operating frequency excursion band	has the meaning given to it in the Rules.
operational frequency tolerance band	has the meaning given to it in the Rules.
power system	has the meaning given to it in the Rules.
power system security and reliability standards	has the meaning given to it in the Rules.
publish	has the meaning given to it in the Rules.
region	has the meaning given to it in the Rules.
separation event	means a *credible contingency event* in relation to a *transmission element* that forms an *island*.

Term	Meaning
synchronisation	has the meaning given to it in the Rules.
system frequency	means the frequency of a part of the *power system*, including the *frequency* of an *island*.
transmission element	has the meaning given to it in the Rules.

B NEMMCO – Case study

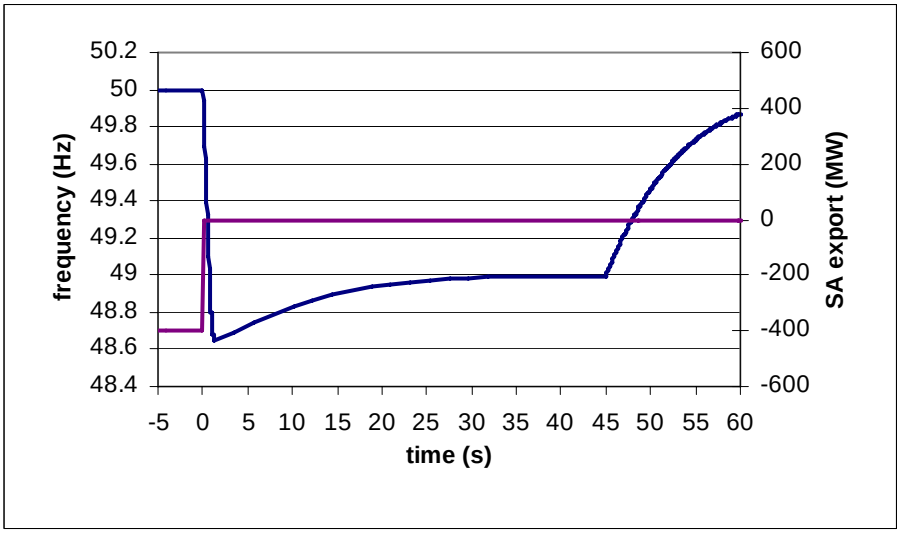
This Appendix contains two case studies based on the scenarios of a multiple contingency event leading to separation of the SA Region and UFLS operation. The SA demand prior to separation is around 1500 MW.

B.1 Case 1: Minimum frequency allowed following loss of largest unit (about 250MW) during supply scarcity is set as 48.0Hz

Refer attachment 1 for the UFLS schedule to be implemented in South Australia.

Note that the time delayed (i.e. 20, 30, 40 and 50 sec) UFLS load blocks have not been modeled in these simulations, for convenience.

Then based upon the UFLS settings to be implemented shortly no FCAS would be required in the island to cover this contingency provided the frequency did not fall below about 48.65Hz. The minimum frequency should stay above this value provided that the total loss of supply (local generation plus supply from other regions) from the initial event did not exceed about 400 MW.



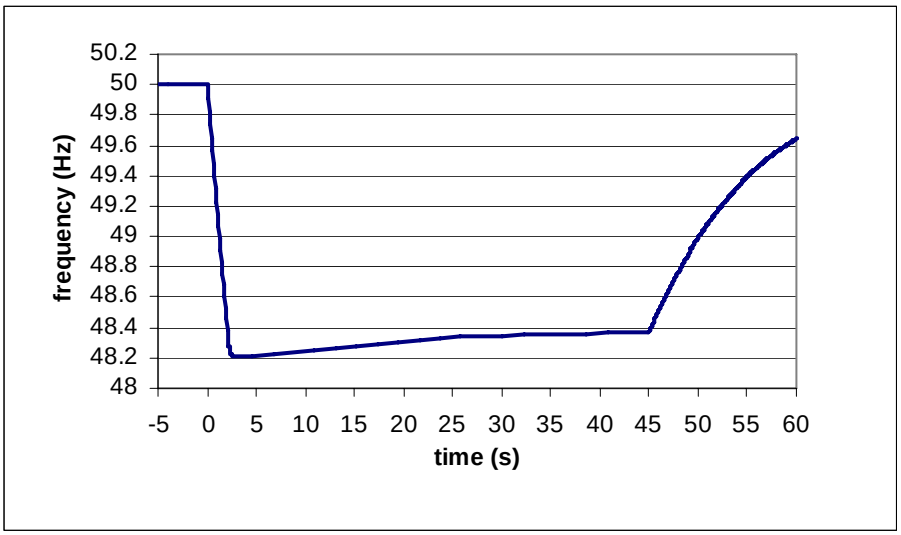
Note that loss of supply could exceed 400 MW for loss of the Heywood interconnector alone but this would occur only in limited circumstances. Based upon immediate past history the flow on the Heywood interconnector from Victoria to South Australia would be expected to exceed 400 MW only about 0.06% of the time.

The estimated UFLS operation would be as follows:

Type of load shedding	Amount of Load Shedding (MW)	Frequency (Hz)	Time of operation (sec)
UFLS	62	49	0.90
UFLS	62	48.95	0.94
UFLS	61	48.9	0.98
UFLS	60	48.85	1.02
UFLS	59	48.8	1.07
UFLS	60	48.7	1.36
Manual	35		45.00

Estimated load of 35 MW has to be manually shed (simulated 45 seconds after the separation for the purpose of demonstration) to restore the frequency to 50Hz.

Once the frequency has stabilized, loss of a 250MW generator in the separated South Australia was simulated with the assumption that the previously shed load on the operation of UFLS has not been restored. Recovery of the frequency with the operation of UFLS is shown in the following graph.



It is noted that the initial frequency deviation is contained marginally above 48Hz in this case.

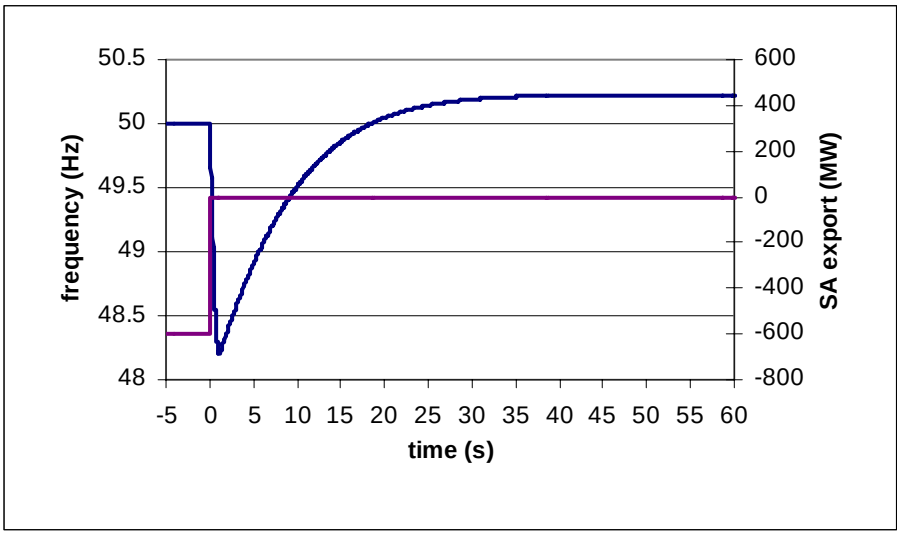
Estimated load of 45 MW has to be manually shed (simulated 45 seconds after the separation for the purpose of demonstration) to restore the frequency to 50Hz. The operation of UFLS has been summarized in the following table.

Type of load shedding	Amount of Load Shedding (MW)	frequency (Hz)	Time of operation (Sec)
UFLS	26	48.6	2.05
UFLS	60	48.5	2.19
UFLS	60	48.4	2.33
UFLS	59	48.3	2.48
Manual	45		45.00

B.2 Case 2: Minimum Frequency Allowed following loss of largest unit (about 250MW) during supply scarcity is set as 47.5Hz

Then based upon the UFLS settings to be implemented shortly no FCAS would be required in the island to cover this contingency provided the frequency did not fall below about 48.2Hz. The minimum frequency should stay above this value provided that the total loss of supply (local generation plus supply from other regions) from the initial event did not exceed about 600 MW.

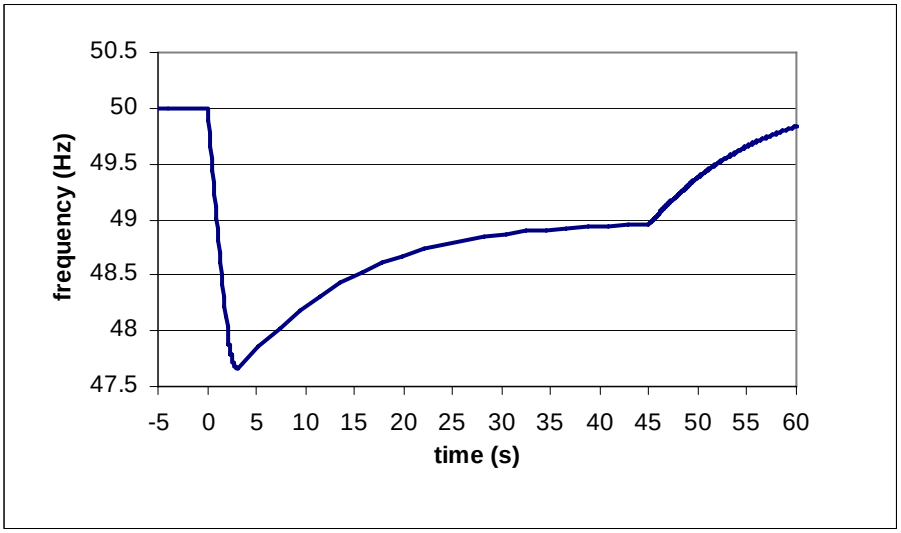
Frequency recovery on the operation of UFLS is shown on the following graph. It is noted that manual load shedding will not be required in this case.



The operation of UFLS has been summarized in the following table.

Type of load shedding	Amount of Load Shedding (MW)	frequency (Hz)	Time of operation (Sec)
UFLS	62	49	0.55
UFLS	62	48.95	0.57
UFLS	61	48.9	0.60
UFLS	60	48.85	0.62
UFLS	59	48.8	0.64
UFLS	60	48.7	0.83
UFLS	61	48.6	0.88
UFLS	60	48.5	0.94
UFLS	60	48.4	1.04
UFLS	59	48.3	1.13

Once the frequency has stabilized, loss of a 250MW generator in the separated South Australia was simulated with the assumption that the previously shed load on the operation of UFLS has not been restored. Recovery of the frequency with the operation of UFLS is shown in the following graph.



The operation of UFLS has been summarized in the following table. Estimated load of 25 MW has to be manually shed (simulated 45 seconds after the separation for the purpose of demonstration) to restore the frequency to 50Hz.

Type of load schedding	Amount of Load Shedding (MW)	frequency (Hz)	Time of operation (Sec)
UFLS	54	48.2	2.15
UFLS	47	48.1	2.26
UFLS	41	48	2.58
UFLS	33	47.9	2.71
UFLS	28	47.8	2.91
UFLS	26	47.7	3.19
Manual	25		45.00

Attachment 1: UFLS schedule to be implemented in South Australia

Frequency setting (Hz)	UFLS Bolck (MW)	Time (sec)	Interlock (Hz)
49.0	62	0.15	
49.0	9	20 delay	49.5
49.0	9	30 delay	49.5
49.0	9	40 delay	49.5
49.0	9	50 delay	49.5
48.95	62	0.15	
48.9	61	0.15	
48.85	60	0.15	
48.8	59	0.15	
48.7	60	0.3	
48.6	61	0.3	
48.5	60	0.3	
48.4	60	0.3	
48.3	59	0.3	
48.2	54	0.3	
48.1	47	0.3	
48	41	0.5	
47.9	33	0.5	
47.8	28	0.5	
47.7	26	0.5	
47.6	24	0.5	
47.5	22	0.5	