National Electricity Market
Management Company Limited
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Proposed Frequency Operating Standard During Supply Scarcity Choice of Critical Minimum Frequency

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FINAL

1. Introduction

The proposed change to the frequency operating standard during periods of supply scarcity would in the mainland regions allow the frequency to be controlled following the credible contingency event at least partially through under frequency load shedding provided that the frequency did not fall below a specified minimum level (described below as the "critical frequency").

2. Relative Risks Associated with Options for Critical Frequency

Difference in Level of Risk between a setting of 48.0 Hz and a setting of 48.5Hz

The table below shows all cases where major generating plant in the mainland regions has a minimum frequency specified in their generator performance standards set at 48.0 Hz or higher.

From this table it can be seen that a reduction in the setting of the minimum frequency in the frequency operating standard to apply during periods of supply scarcity from 48.5 Hz to 48.0 Hz would mean that

- In the Victorian Region between 1400 MW to 2600 MW of plant (depending upon conditions) would no longer have an obligation to remain in service;

- In the NSW Region under some conditions about 3600 MW of plant would no longer have an obligation to remain in service

during such events. However as can be seen from the reasons for these determinations outlined in the table below there is no clear evidence that this plant will actually trip. All that can be said is that there would be some unquantified increase in risk if the frequency falls below 48.5 Hz.

NEMMCO's view is that it is not a certainty that the above plant will trip if the system frequency falls below the minimum frequency set in their performance standards. This is because:

1. In most of the cases above there is similar plant within the same region which have minimum frequencies set in their performance standards at considerably lower values than the values set for the plant above.
2. The minimum frequencies have not been determined on the basis of direct mechanisms such as the setting of an under frequency tripping relay but rather on a view that the value represents a point beyond which risk to the plant increases. The level of increased risk has however not been quantified.

Table removed as it contained commercially sensitive information

3. Relative Benefits Associated with Options for Critical Frequency

Scenarios Examined

This is difficult because the benefit will vary considerably depending upon the scenario involved. Thus the relative benefits of only a small number of the more likely scenarios have been studied as follows

- islanding of SA region - already done
- islanding of Queensland Region
- islanding of Vic and SA Regions (with Basslink operating at full export level into Victoria)

The results show the difference between the benefits between the two options and the present situation on the basis of the range of the size of the events for which additional load would be able to be restored.

Because the actual probability of the various size events occurring is uncertain a simple comparison in terms of expected values of unserved energy will not be possible.

4. Nature of Analysis Undertaken

The analysis is a simplified one which assumes that the minimum frequency following a credible contingency is determined when the total demand reduction due to both load shed by under frequency relays and inherent load relief is equal to the size of the contingency. In reality there is likely to be some overshoot. This is catered for the purposes of this analysis by establishing a safety margin of 0.1 Hz[1]. The analysis takes a conservative view that all generating units prior to the credible contingency event are fully loaded and thus cannot provide any support through governor action. Since some raise regulating service will need to be maintained to ensure adequate frequency regulation this is a conservative assumption. However as this paper is looking at relative benefits then this simplification is considered acceptable.

The analysis operated as follows

Let Total available supply for region (MW) after the initial event be as

Inherent Load Relief Factor be Ir

Critical Minimum Frequency (Hz) be Fc

Total potential demand connected to be shed by UFLS at settings above the critical frequency be Ls in MW

Largest Critical Contingency (MW) be Cc

Now if the largest credible contingency is to be managed without the need to provide additional generation reserve then

Cc = Las + K* (As – Las)

Where Las is the actual load shed to restore frequency after the critical contingency event

And K is the portion of actual load relief assuming frequency falls to the critical frequency

K = Ir*(50-Fc)/50

On this basis the actual load required to be shed by UFLS can be estimated as follows:

Las = (Cc- K*As) /(1-K)

The analysis also takes into account the fact that load shedding to maintain the supply demand balance will also reduce the amount of load available to be shed by UFLS relays with settings above the critical frequency. For the purposes of this analysis the following assumptions have been made

[1] In establishing the settings for the actual procedure NEMMCO will use models which take into account the dynamics of the situation.

- load will be shed in strict priority order; and
- the UFLS settings reflect the load shedding priority order.

In practice due to the need to rotate load shedding these assumptions may not be strictly correct . However they are adequate for the purposes of this analysis[2].

This analysis also assumes that market loads are not available to provide frequency control ancillary services. Of course if they were available in a specific case then these would be the first choice.

5. Assumed Values for Analysis

The values assumed in the analysis are as follows

Demand (D) = 1200 MW for SA Island
= 4500 MW for Queensland Island
= 5500 MW for Victoria and SA Island

The demands assumed are light load demands. These have been chosen as frequency control is typically more difficult under light load conditions as inherent load and size of UFLS blocks are generally lower and the largest credible contingency is likely to represent a greater proportion of total supply.

Inherent Load Relief Factor (Ir) = 1.5 for all mainland regions

Based upon the standard UFLS profile established for all mainland regions the approximate percentage of regional shed by under-frequency if the frequency falls to just 0.1 Hz above the critical frequency is as follows:

Critical Frequency Fc (Hz)	Percentage of Load shed by UFLS
49.0	0 %
48.5	32 %
48.0	47%

Critical Contingency Cc = 260 MW for SA Island
= 700 MW for Queensland Island
=520 MW for Victoria and SA Island

6. Results of Analysis

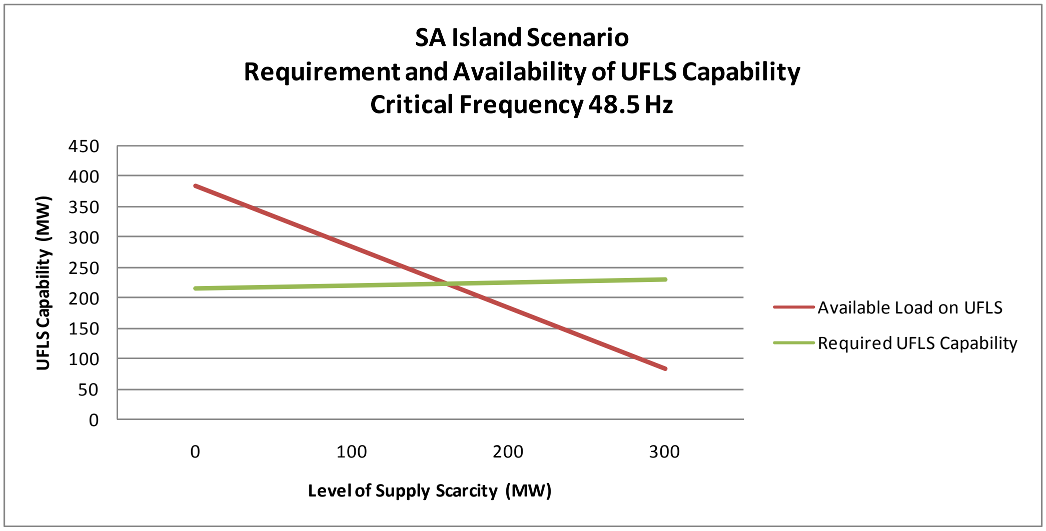
(1) SA Island Scenario

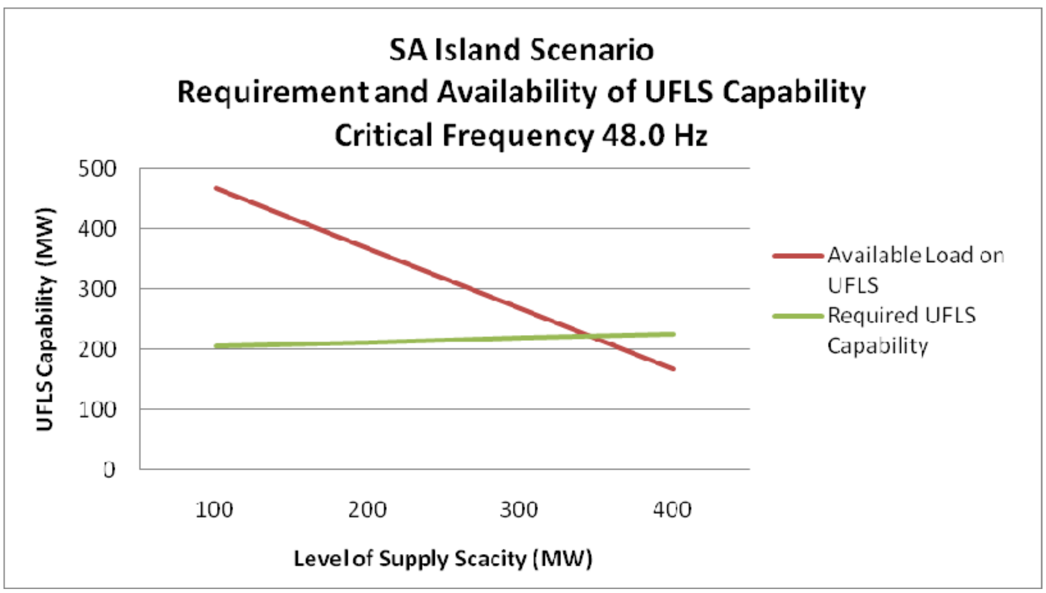
The charts below show for the two options for the critical frequency setting for different levels of supply scarcity

[2] In developing the actual procedure NEMMCO will ensure that it takes into account such practical issues.

1. the requirement for UFLS capability to avoid the need for generation capacity to be kept in reserve to cover the largest credible contingency; and
2. the availability of load connected to UFLS with settings above the critical frequency.

In this case supply refers to the available capacity of generation within the region or provided by Murraylink.





The results above show under the proposed frequency standard for this scenario that

- For a critical frequency of 48.5 Hz no generator reserve would be required to manage the largest credible contingency for levels of supply scarcity of up to about 160 MW; and
- For a critical frequency of 48.0 Hz no generator reserve would be required to manage the largest credible contingency for levels of supply scarcity of up to about 340 MW.

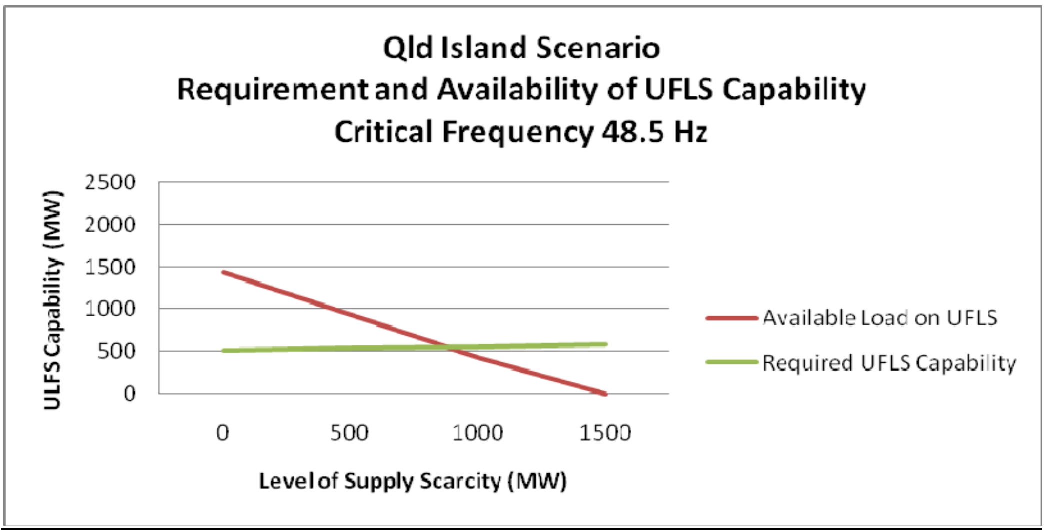
For levels of supply scarcity beyond these values some generation reserve would need to be created by shedding further load. However this load would have to be load connected to UFLS relays with settings above the critical frequency.

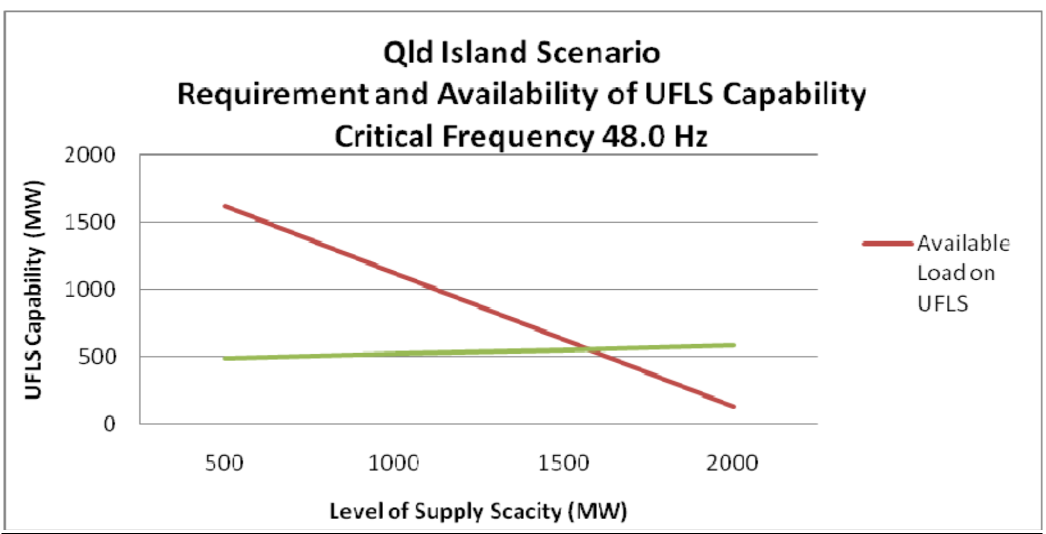
(2) Qld Island Scenario

The charts below show for the two options for the critical frequency setting for different levels of supply scarcity

1. the requirement for UFLS capability to avoid the need for generation capacity to be kept in reserve to cover the largest credible contingency; and
2. the availability of load connected to UFLS with settings above the critical frequency.

In this case supply refers to the available capacity of generation within the region.





The results above show under the proposed frequency standard for this scenario that

- For a critical frequency of 48.5 Hz no generator reserve would be required to manage the largest credible contingency for levels of supply scarcity of up to about 900 MW; and
- For a critical frequency of 48.0 Hz no generator reserve would be required to manage the largest credible contingency for levels of supply scarcity of up to about 1600 MW.

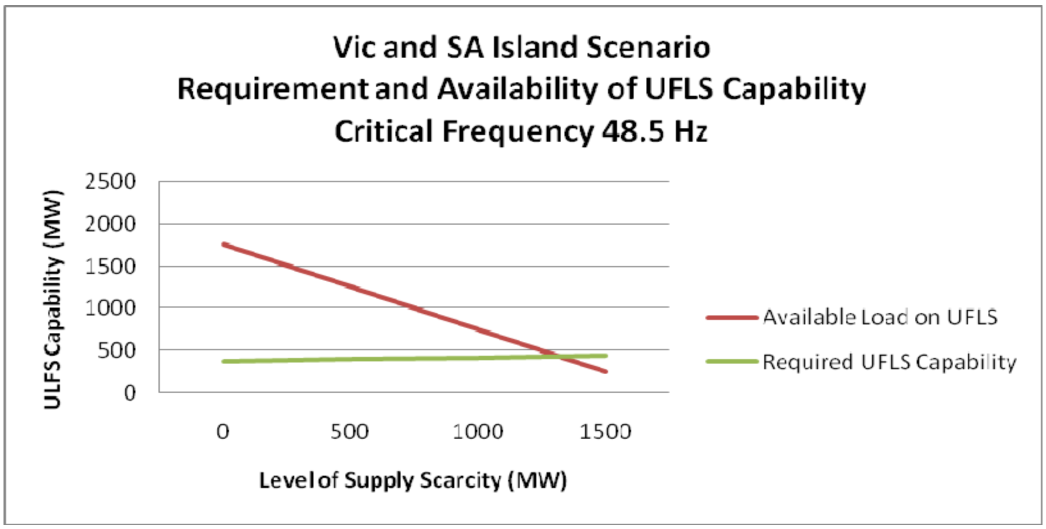
For levels of supply scarcity beyond these values some generation reserve would need to be created by shedding further load. However this load would have to be load connected to UFLS relays with settings above the critical frequency.

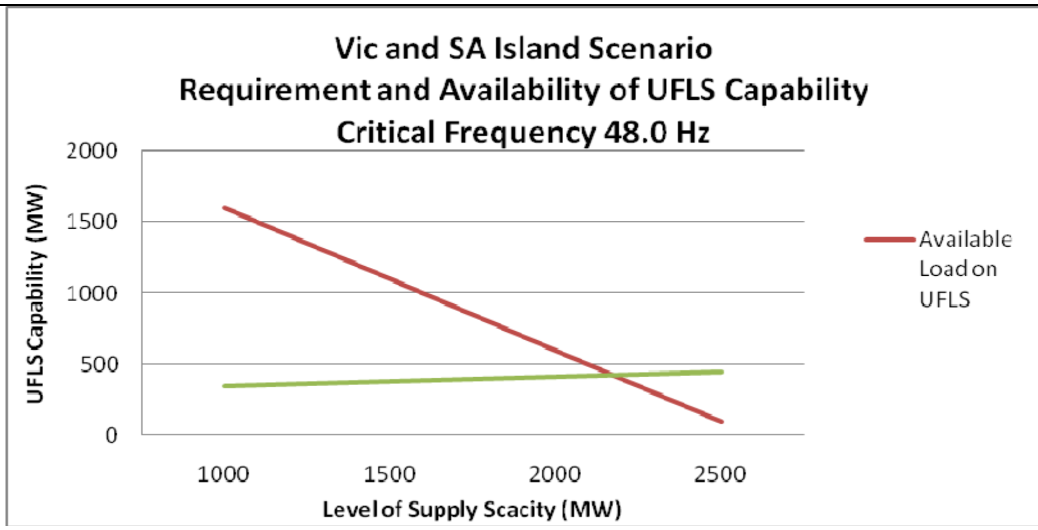
(3) Vic and SA Island Scenario

The charts below show for the two options for the critical frequency setting for different levels of supply scarcity

1. the requirement for UFLS capability to avoid the need for generation capacity to be kept in reserve to cover the largest credible contingency; and
2. the availability of load connected to UFLS with settings above the critical frequency.

In this case supply refers to the available capacity of generation within the region.





The results above show under the proposed frequency standard for this scenario that

- For a critical frequency of 48.5 Hz no generator reserve would be required to manage the largest credible contingency for levels of supply scarcity of up to about 1400 MW; and
- For a critical frequency of 48.0 Hz no generator reserve would be required to manage the largest credible contingency for levels of supply scarcity of up to about 2200 MW.

For levels of supply scarcity beyond these values some generation reserve would need to be created by shedding further load. However this load would have to be load connected to UFLS relays with settings less than the critical frequency.

7. Conclusion

The results above show that a choice of the critical frequency as 48.0 Hz rather than 48.5 Hz would create significant benefits in extending the range of supply scarcity scenarios for which additional load would not be required to be shed to maintain the frequency operating standard.

However the choice of the critical frequency as 48.0 Hz rather than 48.5 Hz would increase the risks involved in this arrangement. Estimating a trade – off between the relative risks and benefits is not possible since, as detailed above, the increased risk cannot, on the basis of the information available to NEMMCO, be quantified.

Because of this, NEMMCO recommends a course of action as follows:

- The Critical Frequencies for the Queensland and South Australian regions be nominated as 48.0 Hz since from the performance standards there seems to be only a small increase in risk[3] in adopting this value rather than 48.5 Hz for these regions;

[3] This is related to an increased risk of plant not complying with their performance standards which cannot be quantified but is likely to increase as the critical frequency is reduced.

- The Critical Frequencies for the NSW and Victorian regions be nominated as 48.5 Hz since from the performance standards there is an increased risk of uncertain magnitude in adopting the alternative value of 48.0 Hz; and
- In cases where an island incorporates more than one region then the critical frequency to be adopted be the maximum value of the critical frequencies for these regions (e.g. for an island comprised of the regions of Victoria and South Australia the critical frequency would be 48.5 Hz).

This approach could be reassessed in the future if more information could be provided on the risks inherent in plant which have high minimum frequencies specified in their performance standards.