Australian Energy Market Commission

DRAFT RULE DETERMINATION

National Electricity Amendment (Emergency frequency control schemes) Rule 2016

Rule Proponent

South Australian Minister for Mineral Resources and Energy

22 December 2016

RULE CHANGE

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About the AEMC

The AEMC reports to the Council of Australian Governments (COAG) through the COAG Energy Council. We have two functions. We make and amend the national electricity, gas and energy retail rules and conduct independent reviews for the COAG Energy Council.

Summary

The Australian Energy Market Commission (AEMC or Commission) has made a draft rule and draft determination to enhance the frameworks for emergency frequency control in the National Electricity Market (NEM).

The draft rule:

- Establishes an enhanced governance framework for the development of a national emergency frequency control scheme (EFCS).
- Introduces a new category of contingency event, the protected event, and a supporting governance framework.

Emergency frequency control schemes are the last line of defence to protect against a major supply disruption and potentially a black system, following a significant disturbance to the power system.

The draft rule enhances the National Electricity Rules (NER or the rules) frameworks to allow for the use of all available technologies, where these technologies provide the most efficient solution for emergency frequency control. The draft rule also sets out a framework for the development of schemes to limit the consequences of over-frequency events.

The draft rule also introduces a new category of contingency event, the protected event. This will allow the Australian Energy Market Operator (AEMO) to manage the power system at all times so that the frequency will stay within defined limits for these events, by using a mixture of ex-ante solutions as well as ex-post controlled load shedding.

Currently, AEMO manages the power system at all times so that, for those events it considers are reasonably possible to occur (known as a credible contingency event), the frequency would stay within defined limits and there would be no ex-post controlled load shedding. It does this by using ex-ante solutions such as the application of constraints to generation dispatch and frequency control ancillary services (FCAS).[1]

AEMO only does this for events that it considers reasonably possible in the surrounding circumstances. For all other events (events that it does not consider are reasonably possible to occur in the surrounding circumstances, known as non-credible contingencies), consequences are primarily limited through controlled load shedding.[2]

The new category of protected event will include events that, while not classified as credible contingency events, could nevertheless have significant economic consequences if unaddressed. AEMO will be able to manage the system at all times by taking some ex-ante actions to limit the potential consequences of these protected events, as well as being able to shed load and/or generation, if the event were to occur.

1 FCAS are services typically procured from generators, where the generator will increase (or decrease) its output to arrest a change in frequency caused by a contingency event. These services are classified by the speed at which the increase or decrease in output occurs, as 6 second, 60 second or 5 minute raise and lower contingency FCAS.

2 In some instances, the consequences of non-credible contingency events are limited through the use of special protection schemes. These schemes are described in more detail in Chapter 3.

As power system operator, AEMO has discretion to reclassify non-credible contingency events to credible, where it considers that abnormal conditions in the power system mean that the occurrence of an event has become reasonably possible. AEMO has developed its Power System Security Guidelines, which set out its processes for deciding how to exercise this direction. This is a separate process to the identification and determination of a protected event.

Frequency in the NEM

The NEM typically operates around a frequency of 50Hz per second.[3] This frequency is the same across the entire synchronised, alternating current NEM power system.

The frequency is related to the balance of load and generation. When there is too much load relative to generation, the frequency falls, and where there is too much generation relative to load, the frequency increases. AEMO manages the system so that generation and load are in balance and the frequency stays close to 50Hz.

AEMO does this in two ways, reflecting different kinds of events that could create an imbalance between generation and load, such as sudden loss of a generator or a transmission line:

- For events that AEMO considers reasonably possible in the surrounding circumstances, called credible contingency events, AEMO manages the system at all times so that if the event were to occur, the frequency will stay within defined limits. AEMO does this by constraining the dispatch of generation and therefore changing the configuration of the power system and / or procuring FCAS. Both application of constraints and FCAS are designed to arrest a frequency change and allow the frequency to return to the normal operating frequency band within a defined timeframe, following the credible contingency event. Importantly, there is no controlled load shedding when one of these events occurs.

  There are likely to be significant costs associated with the ongoing use of such ex-ante solutions, including the costs of buying FCAS from the market and the market impacts of applying constraints to generation dispatch.
- For events that AEMO considers not to be reasonably possible in the surrounding circumstances, called non-credible contingency events, AEMO does not manage the system at all times to keep frequency within specified frequency bands, if the event were to occur. Instead, under-frequency load shedding schemes are intended to arrest the fall in frequency, if the event occurs.

As noted above, AEMO has the discretion to reclassify events from non-credible to credible contingency events. Once it does this, AEMO then manages the system at all times so that if the event occurs, the frequency will stay within defined frequency bands. As discussed above, it does this by applying constraints to generation dispatch and procuring FCAS. No load shedding will occur for the event.

3 Specifically, the power system frequency is generally within a range called the normal operating frequency band. This is defined in the frequency operating standards, which are determined by the Reliability Panel. When the system is operating normally (not in island mode or being restored from a contingency event) the normal operating frequency band is the range of frequency from 49.85Hz to 50.15Hz.

Existing under-frequency load shedding schemes

Currently, the frequency impacts of non-credible contingencies are limited through under-frequency load shedding (UFLS).

UFLS attempts to stop the fall in frequency that can occur following a non-credible contingency, such as the simultaneous trip of multiple generators or transmission lines.

UFLS is facilitated by relays that automatically disconnect blocks of load in a controlled manner when a fall in frequency is sensed. These relays may be programmed to trigger when they sense a particular threshold ***value*** of frequency has been reached, and / or when they sense a particular ***rate*** of change of frequency (RoCoF) has occurred.

In either case, UFLS relays will disconnect blocks of load in an attempt to arrest the fall in frequency, and will continue to do so, until the fall in frequency is arrested, or there is no more load available to be shed.

Various factors may affect the ability of UFLS to operate effectively.

The NEM generation mix has traditionally included many large, synchronous generation units. These units provide physical inertia in the system, which has the effect of slowing the RoCoF following a contingency event. As these units retire and are replaced by new generation technology (many of which are non-synchronous generating units), the amount of physical inertia in the system reduces, which increases the potential rate at which frequency can change following a major event.

This increase in RoCoF reduces the effectiveness of existing UFLS arrangements, as the current equipment that facilitates load shedding may no longer operate quickly enough to stop the fall in frequency following some events. This can occur because RoCoF is so high that generators will trip before the UFLS can operate, potentially triggering a cascading failure.[4]

Increases in the amount of distributed generation, such as rooftop solar, are also affecting the ability of current UFLS equipment to operate effectively. As this generation is located within the blocks of load that are shed by UFLS arrangements, it can actually reduce the amount of load that can be shed in response to a drop in frequency. In some extreme circumstances where there are low levels of demand within the load block but high volumes of distributed generation, a load block may actually be exporting power to the grid. If such a load block was shed during an under-frequency event, this could worsen the situation by reducing available generation, resulting in a further fall in frequency.

The existing frameworks also do not include a formal mechanism for generation shedding, if there is an over-frequency event. In some jurisdictions, the risk and consequence of these over-frequency events may have increased, particularly if a heavily loaded interconnector were to trip while at full export. As with under frequency

4 A cascading failure can occur when a frequency disturbance caused by an event, such as a generator tripping, can cause a subsequent generator to trip off the system. This worsens the frequency disturbance, in turn resulting in further generators tripping. This kind of event can result in a situation where all generators trip off and the power system is in a “black system” condition. Once in a black system, the power system can only be restored slowly through the use of system restart ancillary services, resulting in significant costs to consumers and generators.

events, changes in the generation mix means that the faster RoCoF following such an event could cause generators to trip before UFLS can operate, potentially triggering a cascading failure and black system event.

Finally, there are some currently non-credible contingency events where it may be efficient to limit the consequences of the event through a combination of managing the system at all times with FCAS and generation dispatch constraints, as well as allowing some controlled load shedding to occur.

As discussed above, a faster RoCoF following a contingency event may mean UFLS are not fast enough to prevent a cascading failure. This in turn means that some non-credible contingency events, the consequence of which would have previously been limited to an amount of controlled load shedding, may now result in a cascading failure and potentially a black system event.

Given the potential consequences of these events, it may be efficient to manage the system at all times so that if the event were to occur, UFLS mechanisms have a better chance of operating effectively and limiting the consequences of the event to some controlled load shedding.

This may be more efficient overall, if the costs of managing the system at all times, plus the value of any load shed by the UFLS, is less than the avoided costs of the expected consequences of the specific event.

The draft rule proposes a number of changes to enhance the arrangements for emergency frequency control. This includes an enhanced governance framework for EFCS as well as introducing a new category of contingency event, the protected event.

Enhancing the frameworks for emergency frequency control

The draft rule sets out an enhanced governance framework for the development of an EFCS.

This EFCS governance framework removes specific clauses in the NER that require network service providers (NSPs) to facilitate load shedding through frequency sensing relays. By removing this clause that refers to the use of a specific technology type, the draft rule will allow for the potential use of other technological solutions to provide emergency frequency control. This will allow for all available technologies to be utilised, where these technologies represent the most efficient solution for the provision of emergency frequency control.

For example, existing, commercially proven technological solutions such as a special protection scheme could be used to provide enhanced emergency frequency control. These schemes utilise designated sensors and communication equipment to trigger immediate load or generation shedding as soon as a specific event has occurred, such as the trip of an interconnector. As a special protection scheme is triggered by the specific event, rather than a fall in frequency, it may act much faster than a distributed relay based UFLS type system. This allows for a faster response to the event, potentially preventing a change in frequency rather than arresting a change once it has already begun.

The new framework also formalises arrangements for the development of over-frequency schemes. This will allow for more effective management of over-frequency events.

It is important that an EFCS can be developed to meet future conditions and to maintain security of supply for consumers. However, it should also be delivered at an efficient cost to consumers.

The draft rule therefore sets out a transparent governance framework for the development of the EFCS.

Under these frameworks:

- AEMO, in consultation with NSPs, will develop an EFCS proposal. This will set out a range of potential EFCS capabilities and the costs to achieve these different scheme capabilities. These capabilities may include the speed at which the EFCS can respond, the RoCoF that it can manage or whether it has the ability to sense and dynamically adapt to changes in power system conditions.
- The Reliability Panel will undertake a cost benefit analysis. In doing so, it may consider costs such as the costs of equipment needed to deliver a particular scheme capability. It may also consider benefits in terms of the economic costs of a black system event that is avoided through the enhanced scheme capability. In doing so, it may utilise information provided by AEMO in addition to any other information it deems necessary. The Reliability Panel will then determine an EFCS performance standard.
- AEMO will then develop a functional design specification of an EFCS to meet this standard. This will set out the required performance and outputs of the equipment that NSPs will install to implement the EFCS design specification.
- NSPs will then be responsible for implementing the functional design specifications developed by AEMO, to the extent that the equipment needed to meet the functional design specifications falls within the NSP's area of responsibility. The NSP does this by selecting and installing the equipment that can effectively deliver the functional specifications established in AEMO's design, at an efficient cost to consumers.[5]
- Costs incurred by NSPs will be recovered through network charges that are subject to the AER's standard economic regulatory process. The Australian Energy Regulator will assess the efficiency of NSP costs through this process.

The Reliability Panel is the appropriate body to undertake the cost benefit assessment for an EFCS. Its existing functions already include assessing economic trade-offs to determine standards for the NEM, such as the System Restart Standard and the Frequency Operating Standards, as well as making recommendations for the Reliability Standard. Determination of the EFCS standard is consistent with these existing functions.

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5 Depending on the nature of scheme design, AEMO may also take on some implementation role, potentially including making changes to its own IT systems or control equipment. As with other services provided by AEMO, these costs will be recovered through the market fees that are levied on market participants.

AEMO is the appropriate body to undertake the design of the EFCS. Its role as system operator and planner means that it is best placed to deliver a coordinated and effective EFCS design. NSPs are the appropriate organisations to install the equipment necessary to implement AEMO's functional EFCS design specifications (to the extent that the equipment needed to meet the functional specification falls within their area of responsibility) given their technical expertise and detailed knowledge of their own networks.

A new approach for efficient event classification

The draft rule includes a new classification of contingency event, the protected event.

The protected event would allow AEMO to manage the system at all times through the use of some ex-ante solutions such as FCAS and constraining generation dispatch, as well as allowing some controlled load and/or generation shedding, to limit the consequences of specific high consequence events that would currently be classified as non-credible.

This will support more efficient operational outcomes. By managing the system at all times, AEMO may more effectively limit the consequences of a protected event – that is, they may be able to limit the extent of a major supply disruption or avoid a black system. This will deliver more efficient outcomes overall, when the ex-ante costs of mitigation and costs of any controlled load shedding are less than the avoided expected costs of the protected event.

Permanently managing the system to limit the consequences of a protected event may result in significant system costs, including the costs of procuring FCAS and constraining dispatch. The draft rule therefore establishes a transparent governance framework for protected events.

Under these frameworks:

- AEMO decides whether a specific non-credible contingency should be classified as a protected event.
- AEMO then requests the Reliability Panel to develop a post-contingency operating state for the protected event. AEMO provides the Reliability Panel with the following information in its request:
  - a description of the nature of the event and the potential consequences if the event were to occur;
  - a proposed range of post-contingency operating states, being configurations of the power system that AEMO could achieve if the event were to occur. These post contingency operating states may be defined in a number of ways, including specified bands within which the frequency must remain following the event, timeframes to restore the frequency to specified bands and amounts of load or generation that can be shed if the event were to occur;
  - information on the potential ex-ante solutions that could be used to achieve this post-contingency operating state, such as constraining the operation of the power system or procuring FCAS; and

    - the estimated costs of the ex-ante solutions (such as FCAS and constraining generation dispatch) used to achieve each of these post-contingency operating states.

- The Reliability Panel will determine a post-contingency operating state for every non-credible contingency event that AEMO has decided is a protected event. The post contingency operating state determined by the Reliability Panel may include:
    - timeframes to restore the system to specified frequency bands; and
    - maximum levels of generation or load shedding that can occur following the protected event.
- AEMO will manage the system at all times so that the power system will be in a configuration so that it will meet the post-contingency operating state, if the protected event were to occur. Importantly, AEMO will be able to utilise all available ex-ante solutions to do this, including procuring FCAS, issuing directions or applying constraints to generation dispatch, as well as allowing some ex-post load shedding, if the event were to occur.
- The various costs associated with meeting the post-contingency operating state will be borne by different parties, according to current arrangements. For example, FCAS costs will be recovered from generators and market customers according to the arrangements set out in NER chapter 3, while the costs of constraining generation dispatch may result in increased spot prices for all customers in a region.

System security work package

This draft rule establishes frameworks for emergency frequency control. These are the last line of defence to maintain the security of the system. They are used infrequently to manage events that occur relatively infrequently but which may have high consequences. Because of this, they form a series of regulatory obligations on parties.

The AEMC is also progressing a broader system security work package through its System Security Market Frameworks review. This review is developing mechanisms that will be used to manage the more day to day aspects of the security of the power system, rather than for protecting against extreme emergency events. In contrast to the regulatory frameworks introduced in this draft rule, the system security review will be considering how market mechanisms can be used to provide efficient day to day security solutions on an ongoing basis.

The AEMC recently published an interim report of the System Security Market Frameworks Review. This interim report is available at www.aemc.gov.au

Consultation process

The Commission welcomes stakeholder comment on this draft rule and draft rule determination.

An extended consultation period has been allowed to account for the 2016/17 holiday period.

Submissions are due **16 February 2017.**

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1 South Australian Minister's rule change request and the AEMC's draft rule determination

1.1 The rule change request

On 12 July 2016, the South Australian Minister for Mineral Resources and Energy (the proponent) made a request to the Australian Energy Market Commission (AEMC or Commission) to make two rules for:

- emergency frequency control schemes for generation deficit events;[6] and
- emergency frequency control schemes for excess generation events.[7]

These two rule changes requests were parts B and C of a larger package of rule change requests made by the proponent. This package also included two separate rule changes related to managing RoCoF and fault levels (parts A and D of the package of rule changes). These two rule changes are being considered as part of the AEMC's broader System Security Market Frameworks review.[8]

1.1.1 Structure of this draft determination

The Commission's assessment has been structured to reflect two key proposals made in these rule change requests:

- The development of a governance framework for an EFCS, including mechanisms to limit the consequences of both over-frequency and under-frequency events.
- The development of a new category of contingency event, the protected contingency event (a protected event).

These two components are both related to the management of frequency and protection of the power system. However, there are some differences in terms of their function and what they enable AEMO to do to manage the power system:

- An EFCS is a "last line of defence" emergency mechanism. It is designed to minimise the risk of a cascading failure following a severe disturbance on the power system. It allows load and generation to be shed in a controlled manner following a non-credible contingency event to prevent or arrest a sudden change in frequency that could lead to a cascading outage and potentially a black system, and restore the power system to a secure operating state.[9]

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6 Referred to in this document as the Emergency under-frequency control schemes rule change request.

7 Referred to in this document as the Emergency over-frequency control schemes rule change request.

8 See: http://www.aemc.gov.au/Markets-Reviews-Advice/System-Security-Market-Frameworks-Review

9 NER clause 4.2.6 sets out he power system security principles, which require that there is: Adequate *load shedding* facilities initiated automatically by *frequency* conditions outside the *normal operating frequency excursion band* should be available and in service to restore the *power system* to a *satisfactory operating state* following significant multiple *contingency events*

AEMO does not use any ex-ante mechanisms to limit the consequences of non-credible contingencies,[10] such as buying FCAS or constraining the power system.

- A protected event is a new classification of contingency event. Once AEMO decides that a specific non-credible event is a protected event, and the Reliability Panel has determined a post-contingency operating state for that protected event, AEMO will constantly operate the power system so that it can meet the post-contingency operating state, if the protected event were to occur. This post-contingency operating state may allow some controlled load shedding, if the protected event were to occur.

Given these differences in function, this draft determination considers each of these components separately.

1.1.2 Consolidation of the rule changes

On 22 December 2016, the Commission decided to consolidate the Emergency under-frequency control schemes rule change (ERC0212) with the Emergency over-frequency control schemes rule change (ERC0213) under s 93(1) of the National Electricity Law (NEL).[11] The Commission decided that the two rule change requests ought to be dealt with together because they both related to the emergency management of frequency disturbances following contingency events.

1.1.3 The System Security Market Frameworks review

The AEMC commenced its System Security Market Frameworks review (the system security review) on 14 July 2016 which is considering the market frameworks relevant to system security in the NEM.[12] This review builds on and is being run in collaboration with AEMO's work on technical solutions to system security issues.

As discussed in section 1.1, the system security review incorporates Parts A and D of the package of rule changes proposed by the South Australian Minister for Resources and Energy. These rule change requests relate to rates of change of frequency and system strength.

On 15 December 2016, the AEMC published an interim report on the system security review.

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10 AEMO operates the power system on the basis of managing the frequency following the occurrence of different contingency events. A credible contingency event is an event that AEMO considers is reasonably possible to occur in the surrounding circumstances. They may include events such as the loss of one generating unit or one major transmission line. Non-credible contingency events are contingency events that AEMO does not consider are reasonably possible to occur in the surrounding circumstances. They may include events such as a three phase electrical fault or multiple generation unit failures. Credible and non-credible contingency events are defined in NER clause 4.2.3.

11 Under section 93 of the National Electricity Law, the AEMC may consolidate two or more rule changes that it has received.

12 See: http://www.aemc.gov.au/Markets-Reviews-Advice/System-Security-Market-Frameworks-Review

1.2 Current arrangements

This section describes current NER arrangements for:

- AEMO's management of power system frequency;
- emergency frequency control schemes; and
- processes for contingency event classification and reclassification.

These matters are relevant to both the Commission's consideration of governance arrangements for EFCS and for the development of the new classification of protected event.

1.2.1 Management of frequency

In an alternating current power system, generators export and consumers use electricity within a given range of frequency. Generating equipment and some loads are finely tuned to operate at specific frequencies, so it is important the entire power system remains within a defined frequency range.

One of AEMO's key obligations is to maintain the power system in a secure operating state, which includes keeping system frequency within the normal operating frequency band.[13]

While AEMO aims to keep power system frequency within this band, actual frequency levels are affected by events that change the balance of generation and load. Increases in generation relative to load will tend to increase the frequency, while decreases in generation relative to load will tend to decrease the frequency. AEMO utilises different tools to maintain or return the system to the normal operating frequency band, depending on the nature of the event that has disturbed the frequency.

Minor disturbances during normal operation

When the power system is operating normally, minor fluctuations in supply and demand occur within each five minute dispatch interval. These variations can move the frequency away from the normal operating frequency by a small amount. To manage this, AEMO procures specific ancillary services from generators and loads, known as regulation raise and lower FCAS, and coordinates their use to maintain the frequency within the normal operating frequency band.

Credible contingency events

From time to time, the power system may experience more significant disturbances, where there is a temporary and unexpected imbalance of generation and load. These disturbances, which AEMO considers to be reasonably possible in the surrounding circumstances, are known as credible contingency events. They may be caused by

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13 The frequency requirements that AEMO must meet are defined in the NER and the power system security standard (known as the frequency operating standard (FOS)) determined by the Reliability Panel. NER Chapter 10 defines the normal operating frequency band as: the range 49.9Hz to 50.1Hz or such other range so specified in the *power system security standard*.

events such as the loss of a single generator, a single load or a single line in the network.[14]

AEMO is required to maintain the power system frequency within the operational frequency tolerance band when these kinds of events occur, and must return the frequency to the normal operating frequency band within a specified time period.[15] To do so, it procures contingency raise and lower FCAS, which increase or decrease the frequency in response to these more significant frequency variations.[16]

NSPs also face a number of obligations to plan and operate their networks for credible contingency events. In particular NSPs are required to:

- plan, design, maintain and operate their networks to allow the transfer of power from generating units to customers with all facilities in service, even if a credible contingency event were to occur;[17]
- comply with minimum standards for network services within a region including a power transfer capability such that in a satisfactory operating state, the power system is capable of providing the highest reasonably expected requirement for power transfer (with appropriate recognition of diversity between individual peak requirements and the necessity to withstand credible contingency events) at any time; and[18]
- for power transfers between regions, maintain (with AEMO) a standard of service such that, when in a satisfactory operating state, the network must be planned by the NSP and operated by AEMO to withstand the impact of any single contingency with severity less than the credible contingency events stated in clause S5.1.2.1.[19]

Non-credible contingency events

More rarely, the power system can experience very significant disturbances to the supply/demand balance. These events, which AEMO considers are not reasonably possible in the surrounding circumstances, are known as non-credible contingencies.

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14 NER clause 4.2.3(b) defines credible contingencies as: a *contingency event* the occurrence of which AEMO considers to be reasonably possible in the surrounding circumstances including the *technical envelope*. This definition goes on to describe examples of credible contingencies as: the unexpected automatic or manual *disconnection* of, or the unplanned reduction in capacity of, one operating *generating unit*; or the unexpected disconnection of one major item of *transmission plant* ... other than as a result of a three phase electrical fault anywhere on the *power system*.

15 Chapter 10 of the NER defines the operational frequency tolerance band as: The range of *frequency* within which the *power system* is to be operated to cater for the occurrence of a *contingency event* as specified in the *power system security standards*. The actual values of this range, and related time periods for restoration, are established in the FOS.

16 These contingency FCAS are measured in terms of how rapidly they respond to restore the system to the normal operating frequency. They include 6 second, 60 second and 5 minute frequency raise and lower services. They are typically provided by dispatchable generators who act independently of AEMO to increase or decrease output in response to frequency changes.

17 NER clause S5.1.2.1

18 NER clause S5.1.2.2(a).

19 NER clauses S5.1.2.3(a) and S5.1.2.1.

They may include events such as the simultaneous loss of multiple generators, or the loss of both circuits of a double circuit interconnector between regions.[20]

Currently AEMO does not manage the system at all times, through procurement of FCAS or constraining generation dispatch, in anticipation of non-credible contingencies. Instead, AEMO and network service providers (NSPs) utilise UFLS (and in some instances, special protection schemes) to limit the consequences of a non-credible contingency.[21]

AEMO has the ability to reclassify non-credible contingency events as credible contingency events. It may do this where the presence of abnormal system conditions means that the possibility of an event occurring has become reasonably possible in the surrounding circumstances. As power system operator, AEMO is able to exercise its discretion as to when it considers abnormal conditions exist and have resulted in the event becoming reasonably possible. AEMO describes the criteria it will use to inform the exercise of this discretion in its System Security Guidelines. More information on the reclassification process is provided in section 1.2.4.

1.2.2 National under frequency load shedding schemes

The rules currently set out a national framework for controlled under frequency load shedding (UFLS) for the management of under-frequency events following a non-credible contingency.[22]

UFLS operates only during rare events, usually following a non-credible contingency, where a drop in frequency has not been arrested by FCAS.

UFLS is currently facilitated through a distributed series of relays linked to circuit breakers, which progressively disconnect blocks of load in response to a frequency drop. This disconnection occurs in a coordinated and automatic manner to arrest a fall in frequency. This allows for the process of frequency restoration to the normal operating frequency band to begin.

Importantly, the settings of these relays are coordinated across the NEM. This is because frequency is the same across a synchronised system and moves in the same way when there is a disturbance anywhere in the system. For example, the loss of a

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20 NER clause 4.2.3(e) defines a non-credible contingency as: a *contingency event* other than a *credible contingency event*. The definition then describes examples of non-credible contingencies as: three phase electrical faults on the *power system*; or ... simultaneous disruptive events such as: multiple *generating unit* failures; or double circuit *transmission line* failure (such as may be caused by tower collapse).

21 This obligation is set out in NER clause 4.2.6(c), which describes the power system security principles, being the principles that AEMO must consider in its management of power system security. NER clause 4.2.6(c) states that: Adequate *load shedding* facilities initiated automatically by *frequency* conditions outside the *normal operating frequency excursion* band should be available and in service to restore the *power system* to a *satisfactory operating state* following significant multiple *contingency events*.

22 Current load shedding arrangements are sometimes referred to as a UFLS scheme. The word "scheme" in this context means a technical mechanism that is implemented to automatically control equipment, similar to protection schemes on generating plant. It is not a "scheme" in the more general sense of the word, in that it does not involve any payments made to participants to provide specific services.

generator in Queensland will result in a drop in frequency across the whole of the NEM. Because frequency moves in this way, this drop can be arrested effectively by opening relays in South Australia, Victoria, New South Wales or Queensland, if the frequency has moved outside of the operational frequency tolerance band.

The design of current UFLS arrangements reflects this outcome. Typically, different relays will be set to open at different levels of frequency.[23] These settings are coordinated across the NEM so that load shedding is spread evenly across the different regions.

The NER includes a framework that sets out some responsibilities for different parties regarding the design and implementation of UFLS arrangements. These high level obligations include:

- The jurisdictional system security coordinator (JSSC) is required to establish a schedule of:[24]
    1. sensitive loads, which sets out the priority order, in terms of security of supply, that each load specified in the schedule has over other loads and the loads for which approval of the JSSC must be obtained by AEMO before AEMO can interrupt supply to the load; and
    2. other loads, which set out the order in which non-sensitive loads may be shed by AEMO for the purposes of load shedding.
- AEMO must develop, update and maintain a set of procedures for each participating jurisdiction under which loads will be shed and restored in accordance with the priority order schedules prepared by the JSSC for that jurisdiction.[26]
- NSPs and market customers have a series of obligations including:[27]
    — NSPs are required to ensure that sufficient load is under the control of under-frequency relays at the frequency settings developed by AEMO, to ensure that in the event of the sudden, unplanned simultaneous occurrence of multiple contingency events, the power system frequency does not move outside of the extreme frequency tolerance limits.

      During an under-frequency event, these loads are automatically disconnected in accordance with the procedures established by AEMO. The primary obligation on NSPs is to ensure that sufficient load is available for shedding

    — Market customers with expected peak demand at their connection point in excess of 10MW are required to provide automatic interruptible load. The

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23 This applies when the frequency in all mainland NEM regions is synchronised and there is no separation of regions. Tasmania operates as a separate, non-synchronised part of the NEM and therefore not co-ordinated in this way.

24 NER clause 4.3.2(f)

26 NER clause 4.3.2(h)

27 Various NER clauses including 4.3.4, 4.3.5, S5.1.10.1, S5.1.10.2, S5.1.10.3, S5.3.10 and S5.6.

level of this interruptible load is required to be a minimum of 60% of their expected demand, or at a level determined by the Reliability Panel.[28]

1.2.3 Manual load shedding and localised emergency schemes

The NER also set out other schemes for manual frequency control and to manage localised power system stability issues. These include:

- **Manual load shedding:** Manual load shedding is typically used to manage a supply shortfall and is triggered by AEMO issuing a direction after it has identified specific low reserve system conditions.
- **Localised emergency stability control schemes:** Localised emergency stability schemes are used to manage specific emergency events. These schemes are required to be implemented under NER clause S5.1.8 and typically address power system stability issues within a region, such as voltage, transient and oscillatory stability, or to provide network support.

Both of these arrangements are different to the national emergency under frequency load shedding schemes described above.

Manual load shedding

AEMO has the ability to undertake manual rotational load shedding for the purposes of system security and reliability.[29]

This load shedding is manually initiated by AEMO through directions to NSPs to shed blocks of load. This kind of load shedding is usually undertaken where AEMO has identified a lack of reserve in its projected assessment of system adequacy or in pre-dispatch and that lack of reserve means that a supply shortfall may take place.

This manual rotational load shedding differs from emergency load shedding schemes in that it is manually initiated rather than automatically triggered. It is also usually manually rotated across load blocks to deliver an equitable outcome.

NSP instigated emergency control schemes

NSPs are required to establish localised emergency control schemes for the purposes of maintaining system stability.[30]

Specifically, NSPs must consider the potential consequences of various non-credible contingency events, and to install emergency controls to minimise disruption and the risk of a cascading failure.[31]

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28 This requirement is set out in NER clause 4.3.5.

29 NER clause 4.3.2. More detail is also available in AEMO's Power System Security Guidelines, see: AEMO, *Power System Security Guidelines*, September 2016, p.16.

30 System stability refers to the management of voltage, transient and oscillatory stability in the power system. This is separate to the management of frequency that is currently provided by UFLS.

31 NER clause S5.1.8 requires NSPs, when planning their networks to: consider *non-credible contingency events* such as *busbar* faults which result in tripping of several circuits, uncleared faults, double circuit faults and multiple contingencies which could potentially endanger the stability of the *power system*. In those cases where the consequences to any *network* or to any *Registered Participant* of such events are likely to be severe disruption a *Network Service Provider* and/or a *Registered Participant*

These schemes are typically localised in nature and may deal with matters unrelated to frequency, such as voltage stability and power system oscillations. They may also provide network protection, to prevent overloading and damage to the network following a non-credible contingency event.

For example, SP AusNet proposed and the AER approved two such emergency control schemes in the 2014-17 transmission determination for the period 2014-15 to 2016-17. These consisted of emergency control schemes for the non- credible loss of several major transmission lines, to avoid subsequent tripping of other lines and major load lost within Victoria. These proposed schemes involved load and generator shedding.[32]

These schemes differ from national emergency load shedding schemes in that they are typically designed by a regional NSP, primarily for the purposes of managing intra-regional issues such as voltage stability or network control.

1.2.4 Event reclassification

Current NER obligations

There are a number of different mechanisms that are used to manage the system and to limit the frequency consequences for contingency events. As discussed in section 1.2.1, the rules describe two different kinds of contingency events, credible and non-credible contingency events. Different mechanisms are used for each type of contingency event.

AEMO classifies an event as credible if it considers that the occurrence of the event is reasonably possible in the surrounding circumstances.[33] By default, any other kind of event is classified as a non-credible contingency event.[34]

AEMO has the discretion to reclassify events from non-credible to credible contingencies. This discretion allows AEMO to reclassify a non-credible contingency event when it considers that the presence of abnormal conditions means that the non-credible contingency is now reasonably possible in the surrounding circumstances, due to the presence of abnormal conditions.[35] The NER set out the following obligations on AEMO in regards to the reclassification of events:[36]

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must install emergency controls within the *Network Service Provider's* or *Registered Participant's* system or in both, as necessary, to minimise disruption to any *transmission* or *distribution network* and to significantly reduce the likelihood of cascading failure.

32 See: SP AusNet, *Revised Appendix 6B Network Capability Incentive Parameter Action Plan 2014-17*, December 2013, pp.9-10; and AER, *Final Decision SP AusNet Transmission Determination 2014-15 to 2016-17*, January 2014, p.156. The Commission has been advised that since approval of these schemes by the AER, to date only the load shedding component of the emergency control schemes have been implemented.

33 NER clause 4.2.3(b).

34 NER clause 4.2.3(e) describes a non-credible contingency event as: a *contingency event* other than a *credible contingency event*.

35 Abnormal conditions are defined in NER clause 4.2.3A as: conditions posing added risks to the power system including, without limitation, severe weather conditions, lightning, storms and bush fires.

36 NER clauses 4.2.3A and 4.2.3B.

- AEMO must publish the criteria that it will use as the basis of its reclassification of events. These criteria must be developed in consultation with market participants, NSPs, JSSCs and emergency services agencies.
- When reclassifying an event, AEMO must provide market participants with a notification that a non-credible contingency event has been reclassified as a credible contingency event, describing the abnormal conditions, the relevant non-credible contingency event and other information relevant to AEMO's reclassification.
- AEMO must continue to update any notification as new information arises, until such time as the abnormal conditions have ceased to have a material effect on whether the occurrence of the event remains reasonably possible in the surrounding circumstances. AEMO may then reclassify the event back to non-credible.
- AEMO must report every 6 months setting out its reasons for all instances of reclassification that have occurred in that time.

AEMO's current approach to reclassification

AEMO publishes power system security guidelines, which set out its approach to the reclassification of credible and non-credible events.[37]

These guidelines define two main scenarios that AEMO has considered for reclassification, being the presence of bushfires and lightning near transmission assets. The guidelines then set out detailed decision making processes that AEMO will follow in these scenarios. The guidelines also allow for reclassification for other threats, including multiple generation unit disconnection, impact of pollution on insulators and protection system malfunction, however they do not set out the same detailed decision making processes.

AEMO is able to change the content of these procedures, subject to consultation processes. This includes the detailed scenarios and decision making processes that it will follow when different events occur.

1.3 Rationale for the rule change request

1.3.1 Frameworks for emergency frequency control

In the rule change request, the South Australian Minister for Mineral Resources and Energy stated that a number of emerging power system issues were reducing the effectiveness of existing load shedding mechanisms in the NER. These included:[38]

- **Increases in RoCoF**: in the event of a separation of South Australia from the rest of the NEM, there is an increased risk that existing under-frequency load shedding schemes in South Australia would not work effectively. This was due to the high rates of RoCoF following these events.

37 AEMO, *Power system security guidelines - SO_OP_3715*, 26 September 2016.

38 South Australian Minister for Mineral Resources and Energy, *Rule change submission*, 12 July 2016.

- **Increased distributed energy resources (DER):** insufficient amounts of load could be shed during low frequency events, due to the impact of DER resources, such as rooftop PV in the distribution system.
- **Increased risk and consequence of over-frequency events:** growth of DER and wind generation in South Australia may substantially increase the number of trading intervals when the South Australia region is exporting to the Victoria region, in turn increasing the possibility of an over-frequency event following a non-credible trip of the Heywood interconnector.

  The proponent stated this could be exacerbated by high RoCoF due to low levels of online synchronous generation. This could result in an uncontrolled tripping of generation, in turn lowering frequency and triggering uncontrolled load shedding.

The proponent suggested the existing NER frameworks may impede the use of new technologies that could address these issues. This includes the fact that existing frameworks make no allowance for a scheme to manage the coordinated shedding of generation in response to an over-frequency event.

More generally, the proponent stated the NER framework do not include any process for the review and development of emergency frequency control schemes, which could result in a failure to adapt these schemes quickly enough to remain effective in a rapidly changing power system.

1.3.2 AEMO responsibilities to manage non-credible contingencies

The proponent also stated that the current NER and frequency operating standards (FOS) do not provide AEMO with sufficient guidance regarding the nature of the contingency events for which it must maintain the frequency of the power system.

The proponent stated that under current definitions, AEMO is effectively required to maintain power system frequency for all potential multiple contingency events.[39] It was argued that this is not a realistic requirement, as this could include highly improbable events for which it would be impossible to maintain frequency, such as the simultaneous trip of all generation in a region.

39 This obligation is established in the NER and the FOS. This includes NER clause 4.3.2, which places an obligation on AEMO to: achieve the AEMO *power system security responsibilities* in accordance with the *power system security principles*. NER clause 4.2.6(c) then sets out these principles, which include a requirement that: Adequate *load shedding* facilities initiated automatically by *frequency* conditions outside the *normal operating frequency excursion* band should be available and in service to restore the *power system* to a *satisfactory operating state* following significant multiple *contingency events*. Part B of the FOS require AEMO to maintain the frequency of the power system within the extreme frequency excursion tolerance limits, for any multiple contingency event.

1.4 Solution proposed in the rule change request

The proponent suggested several solutions to address these issues. The key components of that solution are:

- **Under-frequency:** Clarification of the responsibilities of different parties for the management of under-frequency events to facilitate the use of new technologies and solutions.
- **Over-frequency:** Development of a new framework for an over-frequency generation shedding scheme.
- **Event classification:** Introduce a framework in the NER to allow an independent body, such as the Reliability Panel, to nominate specific system events (such as non-credible loss of interconnectors) for which the FOS should be maintained.

1.4.1 Emergency under and over-frequency control schemes

The proponent suggested a number of potential changes to establish a more effective framework for the management of under-frequency events. These included the following:

- A new framework to require NSPs to monitor the ongoing efficacy of load shedding schemes and EFCS and make investments as necessary to maintain their capability
- A new obligation for AEMO and JSSCs to direct NSPs to undertake necessary investments, where NSPs have not done so
- Changes to network planning, performance and reporting obligations
- A review of NER Chapter 6A to ensure that the AER approve all necessary investments by NSPs, assuming they are justified by the NSP or if it is directed to undertake the expenditure by AEMO or the jurisdictional system security coordinator.
- A review and amendment of current NER clause 4.3.5, which requires that market customers with expected peak demand of more than 10MW at a connection point should make up to 60% of their load available for automatic load shedding.
- A new framework for the development of an over-frequency generator shedding (OFGS) scheme to maintain the FOS should a non-credible excess generation event occur. This framework would include the following:
  - AEMO would be required to prepare, maintain and update scheme guidelines that set out how the OFGS would work, including how generation will be shed.
  - When designing the OFGS, AEMO would be required to minimise the amount of generation tripped to arrest over-frequency.
  - Criteria should be established to determine which generation should be shed and when, including that any generators included in the scheme should have high availability factors.

- Any OFGS should contain sufficient redundancy to be effective under a range of operating conditions.
- Clear obligations for generators to participate in any OFGS.

1.4.2 Event classification

The proponent suggested a new framework to allow for the nomination of specific system events for management by AEMO.

Specifically, the proponent suggested that the Commission should add flexible provisions to the NER that would allow an independent body, such as the Reliability Panel, to nominate specific system events, such as the non-credible loss of interconnectors under particular conditions, for which the FOS should be maintained.

The objective of these provisions would be to provide clarity as to which multiple contingency events should be managed and define acceptable levels of consequence in mitigating the most severe outcomes of the specific events.

1.5 The rule making process

On 8 September 2016, the Commission published a notice advising of its commencement of the rule making process and consultation in respect of the rule change request.[40] A consultation paper identifying specific issues for consultation was also published. Submissions closed on 13 October 2016.

The Commission received seven submissions as part of the first round of consultation. The Commission considered all issues raised by stakeholders in submissions. Issues raised in submissions are discussed and responded to throughout this draft rule determination. A summary of other issues raised in submissions and the Commission's response to each issue is contained in Appendix A.

1.6 Consultation on draft rule determination

The Commission invites submissions on this draft rule determination, including the draft rule, by **16 February 2016**.

Any person or body may request that the Commission hold a hearing in relation to the draft rule determination. Any request for a hearing must be made in writing and must be received by the Commission no later than 29 January 2017.

Submissions and requests for a hearing should quote project number ERC0212 and may be lodged online at www.aemc.gov.au or by mail to:

Australian Energy Market Commission
PO Box A2449
SYDNEY SOUTH NSW 1235

40 This notice was published under s. 95 of the National Electricity Law (NEL).

2 Draft rule determination

2.1 The Commission's draft rule determination

The Commission's draft rule determination is to make the draft rule as proposed by the proponent.

The draft rule establishes governance frameworks for:

- the development of enhanced emergency frequency control schemes; and
- the identification and application of a new category of contingency event, the protected event.

This chapter outlines:

- the rule making test for changes to the NER;
- the assessment framework for considering the rule change request; and
- the Commission's consideration of the draft rule against the national electricity objective.

Further information on the legal requirements for making this draft rule determination is set out in Appendix B.

2.2 Rule making test

2.2.1 Achieving the national electricity objective

The Commission may only make a rule if it is satisfied that the rule will, or is likely to, contribute to the achievement of the national electricity objective (NEO).[41] This is the decision making framework that the Commission must apply.

The NEO is:[42]

> "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."

2.3 Assessment framework

In assessing the rule change request against the NEO the Commission has considered the following principles:

- **Proportionality:** When considering the development of new regulatory frameworks for EFCS and protected events, we first considered the materiality of

41 Section 88 of the NEL.

42 Section 7 of the NEL.

current and potential issues and whether they can be adequately addressed under existing frameworks.

In doing so, we considered the extent of potential changes underway in the NEM and the ability of current frameworks to adapt and address the consequences of those changes. Changes were made to the frameworks where we considered it was likely that continuing with existing arrangements would not be in the long term interests of consumers

- **Efficient framework design**: When assessing new regulatory frameworks for EFCS and protected events, we considered whether these frameworks will be able to identify and balance all costs and benefits to determine the most efficient outcome. In dong so, we considered whether the proposed frameworks would be able to:
  - clearly identify and assess all of the potential consequences that would need to be addressed, in order to deliver outcomes that are in the long term interests of consumers;
  - clearly identify and assess the full range of potential solutions to mitigate these potential consequences. This should include the ability to recognise and assess new technologies and services that could provide solutions at lowest cost; and
  - weigh the costs of these different solutions, including any regulatory/administrative costs as well as the costs of physical infrastructure, against the materiality of the uncontrolled extreme frequency event they are designed to mitigate. This should include efficient allocation of costs and risks between parties under different solutions.
- **Effective governance:** When assessing new regulatory frameworks for EFCS and protected events, we considered whether these new frameworks adhered to good governance principles, including:
  - ***Stability and flexibility:*** Efficient investment and operational decisions are supported by confidence in the maintenance of a secure and safe power system. This confidence will be maintained where the regulatory frameworks for power system security are predictable and transparent. Equally however, these frameworks must be sufficiently flexible to adjust to changing market conditions
  - ***Appropriate allocation of responsibilities:*** Roles and responsibilities should be allocated on the basis of experience of organisations. Allocation of responsibilities should also reflect the primary function of the organisation, whether that be of an operational or economic analytical nature
  - ***Clear and transparent objectives:*** Organisations should have clearly defined objectives and adequate operational scope to meet those objectives within the overarching governance framework
  - ***Accountability:*** Organisations should be accountable for how they have met their objectives. This should be enabled through obligations to consult and regular reporting obligations.

2.4 Summary of reasons

The draft rule made by the Commission is attached to and published with this draft rule determination. The key features of the draft rule are:

- An enhanced governance framework for EFCS, which builds on existing load shedding arrangements in the NER and includes arrangements for the management of over-frequency events.
- The introduction of a new classification of contingency event, the protected event, and an accompanying governance framework for the identification, assessment and operational standards associated with these events.

Having regard to the issues raised in the rule change request and during consultation, the Commission is satisfied that the draft rule will, or is likely to, contribute to the achievement of the NEO for the following reasons:

- The new frameworks in the draft rule will enable new technologies and solutions to provide more effective EFCS, improving the security of electricity services for consumers. Similarly, the introduction of the contingency event classification of the protected event will allow for more efficient operation of the power system, providing both security and reliability benefits for consumers.
- Introduction of new governance frameworks will clearly establish responsibilities for cost benefit assessment, design and review of EFCS. This will allow for identification of efficient solutions, supporting long run efficient operation, use and investment in electricity services.

2.5 Strategic priority

This rule change request relates to the AEMC's strategic priority relating to markets and networks.

This strategic priority relates to the flexibility and resilience of energy market frameworks to respond to changes in technology and new business models. This includes changes in the generation mix, such as the retirement of large synchronous units and the increased penetration of non-synchronous generation. This links to the development of a stronger EFCS and protected events, which are both designed to maintain the resilience and security of the power system as the generation mix changes.

Distribution networks are also evolving from one-way energy delivery systems in a growth environment into multi-directional "smart grids". This includes the increasing penetration and impacts of distributed energy resources. As identified in section 1.3.1, these new distributed technologies are already impacting on the ability of UFLS to maintain power system security. The new EFCS governance frameworks will better allow for consideration of how these new technologies may be incorporated into the maintenance of a secure power system.

2.6 Northern Territory legislative considerations

From 1 July 2016, the NER, as amended from time to time, apply in the Northern Territory, subject to derogations set out in Regulations made under the NT legislation adopting the NEL.[43] Under those Regulations, only certain parts of the NER have been adopted in the NT.[44] As the proposed rule relates to parts of the NER that currently do not apply in the Northern Territory, the Commission has not assessed the proposed rule against additional elements required by Northern Territory legislation.[45]

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43 National Electricity (Northern Territory) (National Uniform Legislation) (Modifications) Regulations.

44 For the version of the NER that applies in the Northern Territory, refer to : http://www.aemc.gov.au/Energy-Rules/National-electricity-rules/National-Electricity-Rules-(Northern-Territory).

45 National Electricity (Northern Territory) (National Uniform Legislation) Act 2015.

3 An enhanced governance framework for emergency frequency control

This chapter sets out the Commission's draft changes to deliver an enhanced governance framework for an emergency frequency control scheme in the NER.

This framework provides clear responsibilities for the determination, design, implementation and monitoring of an EFCS.

This chapter:

- sets out the proponent and stakeholder views;
- describes the components of the enhanced EFCS governance framework; and
- discusses some of the key issues the Commission considered in developing the EFCS governance framework.

3.1 Proponent's views

As discussed in Chapter 1, the proponent stated that the current NER frameworks may impede the use of new technologies to deliver effective emergency frequency control. This included the fact that existing frameworks make no allowance for a scheme to manage the coordinated shedding of generation in response to an over-frequency event.

More generally, the proponent stated that the NER do not include any process for the monitoring and adaptation of EFCS, which could result in a failure to develop these schemes quickly enough to remain effective in a rapidly changing power system.

3.2 Stakeholder views

A number of stakeholders commented on the issues raised by the proponent and identified a number of others. Key issues addressed by stakeholders included:

- The materiality of the issues identified by the proponent.
- Adequacy of current governance arrangements and potential new responsibilities for parties.
- New technologies to provide emergency frequency control.
- Over-frequency EFCS.
- Costs associated with an EFCS.

3.2.1 Materiality of the issues identified by the proponent

A number of stakeholders agreed with the proponent that changes in the power system were likely to have a material impact on the ability of existing UFLS to maintain power system security.

The Energy Networks Association (ENA), South Australian Department of State Development and AEMO considered that UFLS may become less effective over time due to the exit of synchronous generation and resultant increases in RoCoF. This was exacerbated by the fact that DER also reduces the assumed size of load blocks. Furthermore, there was an increased risk of uncoordinated loss of generation if an over-frequency event occurred. The materiality of these issues was expected to increase over the medium term.[46] The South Australian Department of State Development stated that limitations on the size of contingency events will help to manage RoCoF.

3.2.2 Adequacy of current governance arrangements and new responsibilities

The ENA and AEMO stated that current regulatory arrangements would be significantly improved if there was greater clarity of the respective roles and obligations for all parties. Clear oversight of the effectiveness of EFCS was important, given the rapidity of energy sector transformation. AEMO also stated that greater clarity was required over roles and responsibilities. AEMO also stated that current frameworks do not allow for consideration of all physical solutions[47]

The South Australian Department of State Development proposed a series of responsibilities for parties under a new governance framework, including:[48]

- AEMO and the JSSC should have the ability to direct NSPs to invest in new technologies.
- NSPs should have planning and reporting obligations with respect to load shedding and EFCS.

3.2.3 New technologies to provide emergency frequency control

RES Australia, Hydro Tasmania and the South Australian Department of State Development stated that current frameworks are not sufficient to consider all cost effective physical solutions to deliver emergency frequency control.[49]

The ENA stated that while current frameworks do not preclude new technology, they do not adequately consider DER or storage options.[50]

The Clean Energy Council suggested that an over-reliance on load shedding could underplay the efficient use of DER and called for a more integrated approach to DER.[51]

Hydro Tasmania also stated that current relay based technologies may no longer be effective. It suggested that emergency special control schemes are more effective and less expensive.[52]

AEMO also stated that the NER should be amended to generalise the description of EFCS so they are not prescriptive as to how they can be operated and at what frequency range they may be expected to trigger.[53]

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46 Consultation paper submissions: Energy Networks Australia.3.; South Australian Department of State Development, p.1,4.; AEMO, p.12.

47 Consultation paper submissions: ENA, p.4., AEMO, p.12.

48 South Australian Department of State Development, Consultation paper submission, p.9.

49 Consultation paper submissions: RES Australia, p.3., Hydro Tasmania, p.3., South Australian Department of State Development, p.9.

50 ENA, Consultation paper submission, p.5.

51 Clean Energy Council, Consultation paper submission, p.1.

52 Hydro Tasmania, Consultation paper submission, p.1.

53 AEMO, Consultation paper submission, p.12.

3.2.4 Over-frequency emergency control schemes

The ENA and RES stated that under-frequency and over-frequency emergency control should be considered together. [54]

The Clean Energy Council (CEC) questioned the need for an over-frequency EFCS. It also suggested that tripping entire wind farms was not an acceptable solution for managing over-frequency, as wind farms can respond to over-frequency through fast ramping. The CEC also stated that AEMO already has powers to set generator responses to over-frequency events in performance standards.[55]

The CEC noted that the introduction of an over-frequency EFCS could provide negative investment signals for renewable energy investment. The CEC stated that the over-frequency EFCS as proposed would be arbitrary and would not provide compensation arrangements for semi-scheduled generators. It was also argued this would also reduce the value of frequency lower services.[56] This issue raised by the CEC is addressed in section 3.4.5.

3.2.5 Costs associated with EFCS

RES Australia noted there were costs to participants if they were required to provide elements of an EFCS.[57]

The South Australian Department of State Development stated that the cost of new or updated EFCS should be assessed together with the cost of procuring services to manage high RoCoF, as any RoCoF standard could affect the cost of upgrading existing UFLS arrangements. It argued that the calculation of costs should include the cost of load shedding as an economic cost to consumers.[58]

AEMO stated that AEMO and NSPs would expect to face design costs, while NSPs would likely be subject to costs for new assets and ongoing maintenance. AEMO stated that the NER should provide for clear, timely and economically efficient mechanisms for NSPs to recover the costs of implementation and on-going operation and maintenance of network and communications infrastructure to allow operation of adaptive EFCS. [59]

3.3 A new governance framework for EFCS

This section provides a brief description of each component of the new EFCS governance framework.

Section 3.4 describes the key issues considered by the Commission in developing this framework.

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54 Consultation paper submissions: ENA, p.3; RES, p.4.

55 CEC, Consultation paper submission, p.2.

56 CEC, Consultation paper submission, p.2.

57 RES Australia, Consultation paper submission, p.4

58 South Australian Department of State Development, Consultation paper submission, pp.10.

59 AEMO, Consultation paper submission, pp.12, 17.

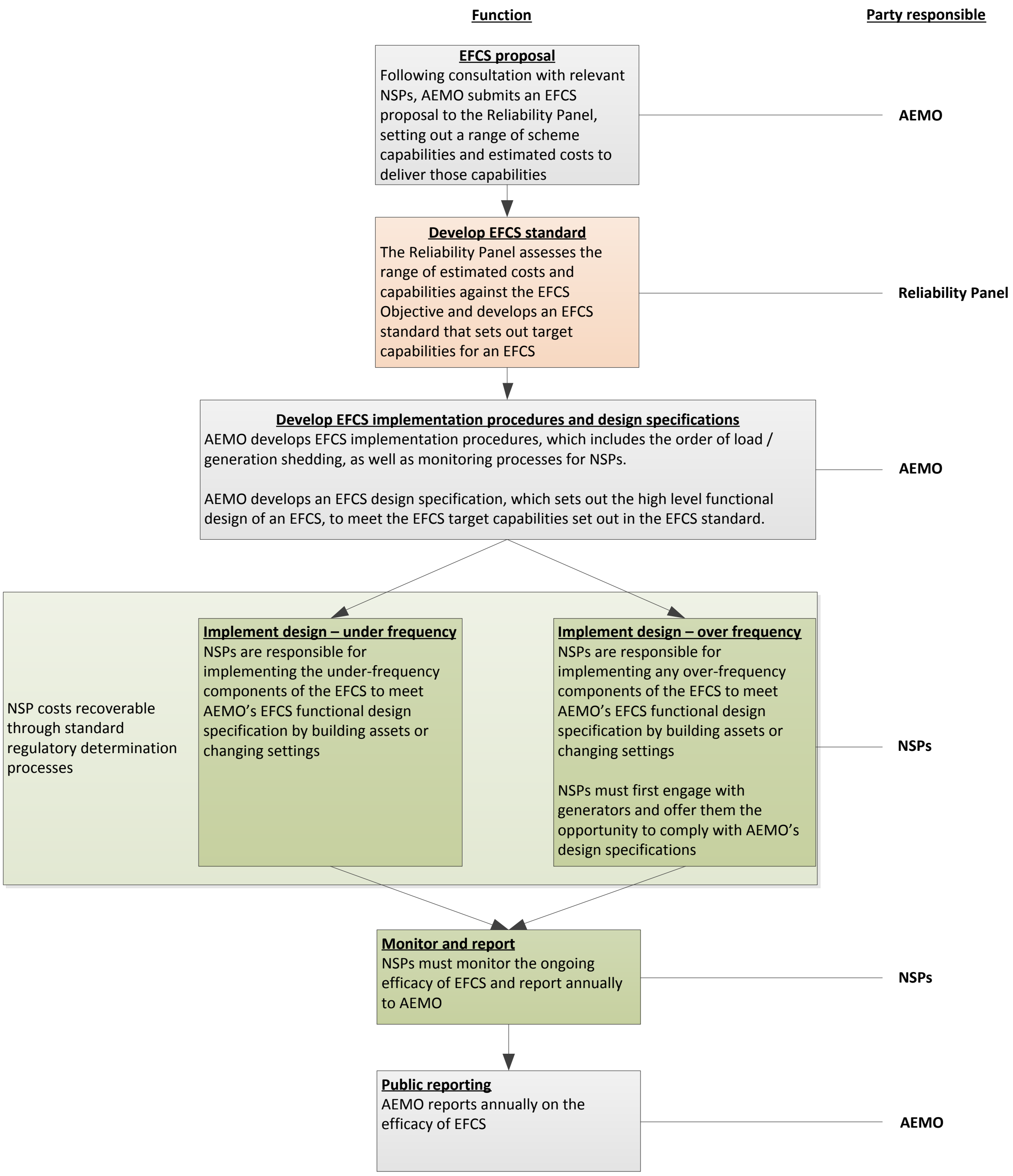
3.3.1 The EFCS governance frameworks

The draft rule sets out a governance framework for the determination, design, implementation and monitoring of EFCS.

This framework builds on existing NER arrangements for UFLS. The Commission has proposed changes to some of these arrangements to modify roles and responsibilities. Some new roles and responsibilities have also been introduced.

This section describes the components of the EFCS governance frameworks. The matters considered by the Commission in developing this framework are discussed in following sections.

Figure 3.1 EFCS governance framework



3.3.2 EFCS Objective

The EFCS Objective describes the purpose of these schemes. It will inform both AEMO and the Reliability Panel in their roles within the EFCS governance frameworks.

The Commission has proposed the following EFCS Objective:

> "The objective for *emergency frequency control schemes* is for these schemes to be available and in operation to the extent appropriate having regard to the *national electricity objective,* to prevent or arrest *cascading outages, major supply disruptions* and uncontrolled increases or decreases in *frequency* (alone or in combination)."

Emergency frequency control schemes are defined as:

> "*facilities* for initiating automatic *load shedding* or automatic *generation shedding* in an orderly fashion."

The EFCS Objective will inform AEMO's EFCS proposal and the Reliability Panel's determination of the EFCS standard.

3.3.3 EFCS proposal

Under the draft rule, AEMO may as it considers appropriate, develop and submit an EFCS proposal to the Reliability Panel.

The EFCS proposal will set out a range of proposed potential scheme capabilities and an estimate of the cost of delivering each of these potential capabilities.

The EFCS proposal will also specify the areas in which the EFCS will apply. As discussed in section 3.4.2, while the EFCS is a national scheme, it may also need to reflect the specific conditions in a region. The EFCS proposal will also specify whether it includes an over-frequency scheme component and / or an under-frequency scheme component[60] as well as a general description of the proposed scheme and why AEMO believes it is required.

In developing the EFCS proposal, AEMO will consult with all relevant NSPs. NSPs will provide all information to AEMO as reasonably requested in order to develop the EFCS proposal and for the development and review of proposed EFCS standards, design specifications and implementation procedures.

An EFCS proposal submitted to the Reliability Panel would contain the following elements:

- the proposed target capabilities for the EFCS, or sets of proposed target capabilities and corresponding expected power system security outcomes, which will include:
  - how quickly the scheme can respond;
  - the power system conditions within which the scheme is capable of responding;

60 In this draft rule determination, the Commission refers to under-frequency schemes and over-frequency schemes, rather than UFLS or OFGS respectively. These schemes are the components of the broader EFCS.

- the nature of the scheme's response (an under-frequency scheme for load shedding or an over-frequency scheme for generation shedding);
- the amount of load shedding or generation shedding that may occur;
- the scheme's capability to dynamically sense power system conditions;

- an estimate of the costs for each of the proposed target capabilities, including costs to procure and commission the scheme and maintain its availability and performance, including upfront costs and ongoing maintenance costs; and
- a general description of the scheme including its functionality, the NSPs and generators likely to be affected, and the assets that AEMO considers will be used to deliver the EFCS. This may include technologies such as relays, communications enabled relays, or special protection schemes.[61]

The Commission considers that only AEMO should be able to propose an EFCS proposal. AEMO is best positioned to understand overall power system conditions, both within and across regions. AEMO must consult with relevant NSPs before submitting its EFCS proposal to the Reliability Panel.

Importantly, AEMO will submit EFCS proposals to the Reliability Panel when this is necessary. In doing so, AEMO will be guided by draft NER clause 4.2.6, which requires there to be an adequate EFCS available and in service to meet the EFCS Objective.

The Commission understands that some components of existing emergency frequency control arrangements remain fit for purpose and may not require significant redesign.[62] As such, the Commission does not require, nor expect, that AEMO would need to include any significant changes to these existing components when submitting an EFCS proposal to the Reliability Panel, as long as the national EFCS remains coordinated and effective across the NEM.

3.3.4 EFCS standard

Once AEMO has submitted an EFCS proposal, the Reliability Panel will assess the proposal and determine the EFCS standard.

The Reliability Panel will determine the EFCS standard in accordance with the EFCS Objective.

The EFCS standard sets out the target capabilities for the EFCS. The EFCS target capabilities are the high level technical parameters that define the service provided by

61 A special protection scheme allows for the controlled tripping of generation or load to limit the frequency consequences following specific contingency events, such as the loss of an interconnector between two regions. Currently, special protection schemes have been implemented in Tasmania to account for the contingent loss of the Basslink DC interconnector and subsequent under or over-frequency events. More information can be found at: Tasmanian Department of State Growth, Tasmania Delivers: Many reasons to invest in renewable energy, August 2016, p.4. Available at http://www.stategrowth.tas.gov.au/__data/assets/pdf_file/0010/138727/Tasmania_Delivers_-_Renewable_Energy.pdf.

62 The Commission understands that in those regions where there is a greater possibility of separating from the rest of the NEM, it is more likely there will be a requirement to redesign of equipment, as opposed to those regions that are less prone to separation.

the scheme. They form the basis of AEMO's EFCS design specifications. They may include, but are not limited to:[63]

- power system conditions within which the scheme is capable of responding;
- the nature of the scheme's response (load shedding or generation shedding for the purposes of managing frequency);
- the speed of the response;
- the amount of load shedding or generation shedding that may occur when the scheme responds; and
- the capability to dynamically sense power system conditions.

The Reliability Panel must publish the EFCS standard together with a report setting out its reasons. This determination must include:

- the rationale for the approved target capabilities applicable to the scheme, which may include a consideration of the expected power system security outcomes;
- the estimated costs to procure, commission and maintain the availability and performance of the scheme; and;
- where applicable, any other target capabilities considered and the corresponding expected power system security outcomes and costs.

The Reliability Panel must publish and consult on its EFCS standard and determination in accordance with the rules consultation procedures.

3.3.5 EFCS implementation procedures and design specification

Once the Reliability Panel has determined the EFCS standard, AEMO will develop the EFCS design specification and EFCS implementation schedule. These documents describe how an EFCS will operate in accordance with the EFCS standard.

When developing these documents, AEMO must consult with affected NSPs for an EFCS, and with affected generators when the EFCS includes an over-frequency control scheme component.

The Commission notes that AEMO already prepares load shedding procedures under the existing NER.[64] The EFCS implementation procedures will include the matters that AEMO is currently required to include in its load shedding procedures, as well as some new requirements.

63 The Commission is not proposing that the NER should set out the specific parameters to be included in the EFCS standard. The Reliability Panel will determine these parameters in consultation with all relevant parties. The parameters listed in the draft rule are provided as guidance on the kinds of matters the Commission considers the Reliability Panel may consider for inclusion.

64 NER clause 4.3.2(h). AEMO is required to develop load shedding procedures that describe which loads will be shed and restored in accordance with priorities set out in schedules developed by the relevant JSSC for that jurisdiction.

EFCS design specification

Following the Reliability Panel's determination of the EFCS standard, AEMO will develop the EFCS design specification.

The EFCS design specification sets out the detailed functional design requirements of an EFCS. These design specifications inform the relevant NSP's EFCS implementation process.

The EFCS design specification must reflect the target capabilities determined by the Reliability Panel in the EFCS standard. EFCS design specifications include:

- a description of the functional specification of the scheme describing in reasonable detail the required operational performance of the scheme consistent with the target capabilities;
- commissioning arrangements;
- the requirements for ongoing monitoring and testing of the scheme once it is in operation; and
- the requirements for reporting to AEMO in relation to the scheme.

EFCS implementation schedules

The EFCS implementation procedures will specify how loads and generation are to be shed by under-frequency schemes and over-frequency schemes, respectively.

For an under-frequency scheme, the current arrangements for the determination of the order of load shedding will continue to apply. That is, the relevant JSSC will continue to provide to AEMO schedules of the priority order of sensitive loads and other loads.[65] AEMO will then set out in the implementation schedules the procedures for each participating jurisdiction that describe the manner in which loads will be shed and restored, in accordance with the priority order established by the JSSC.[66] As under current arrangements, these load shedding schedules will remain confidential.

For an over-frequency scheme, the JSSC will not have a role in determining any priority orders. Instead, the NER will include two principles around which AEMO will determine the manner in which generators will be interrupted or have output reduced. These two principles, in priority order, are that AEMO should determine a manner in which generation will be interrupted or have output reduced that is best calculated to achieve the power system security principles[67] and to that end may determine a sequence and settings that will:

1. restore the system to a *secure operating state*; and then to
2. restore the system to a *reliable operating state.*

The Commission's reasoning in developing these principles is explained in section 3.4.5.

65 NER clause 4.3.2(f).

66 NER clause 4.3.2(h)

67 NER clause 4.2.6.

Monitoring and reporting

The EFCS design specifications will set out a process for NSPs to follow in monitoring and reporting on the ongoing efficacy of an EFCS.

Consultation and development of the EFCS procedures and design specification

When developing the EFCS implementation procedures and EFCS design specification, AEMO will consult with all relevant parties. This includes:

- for under-frequency schemes, relevant NSPs; and
- for over-frequency schemes, relevant NSPs and generators.

As the high level capabilities of the EFCS will be subject to a public consultation process through the Reliability Panel's development of the EFCS standard, AEMO is not required to publish its EFCS procedures. This is in keeping with current arrangements for the development of AEMO's load shedding procedures.

3.3.6 EFCS implementation

Once AEMO has developed its EFCS implementation procedures and design specification, AEMO and the relevant NSPs must begin the process of implementing the EFCS. This process includes:

- build of assets and / or changes to settings of existing assets, to implement under and over-frequency scheme components of the EFCS; and
- monitoring and reporting on the ongoing efficacy of the EFCS.

Implementation process

NSPs must engage with and cooperate with all other relevant NSPs in the implementation of AEMO's EFCS design specifications. This is in keeping with current arrangements for cooperation between TNSPs and DNSPs in the development of load shedding schemes.[68]

Broadly, NSP's responsibilities for implementation are to build assets and / or change settings on existing assets, to comply with the functional design requirements set out in AEMO's EFCS design specification.

NSP responsibilities differ for the implementation of under-frequency schemes and over-frequency schemes:

- For any under-frequency scheme, NSPs must install equipment and / or change equipment settings as needed, to meet the EFCS design specifications.
- For any over-frequency scheme, NSPs must:
    1. engage in good faith with generators and offer generators the option of building assets or changing settings on existing assets to comply with the EFCS design specifications; and

68 NER clause S5.1.10.1 states that: Arrangements for *load shedding* must be agreed between *Transmission Network Service Providers* and connected *Distribution Network Service Providers* and may include the opening of circuits in either a *transmission* or *distribution network*.

2. if a generator elects not to undertake the actions referred to above, or good faith negotiations do not result in agreement being reached in reasonable time, build assets and/or change settings on existing assets to comply with the EFCS design specifications.

The Commission's rationale for developing these arrangements is set out in section 3.4.4.

Monitoring and reporting

NSPs must develop and administer testing arrangements that comply with the testing regime established in AEMO's EFCS design specifications. NSPs must comply with any requirements placed on them by AEMO in this testing regime.

NSPs must report to AEMO periodically, on the matters defined by AEMO in its EFCS procedures.

AEMO must prepare, in consultation with relevant NSPs, and publish, a report on the operation and efficacy of the EFCS.

3.4 Commission's considerations in developing the EFCS governance framework

The EFCS governance framework has been designed to:

- provide a nationally coordinated approach to the development of the EFCS, while allowing for jurisdictional differences where this is necessary;
- allow for all technologies to be utilised where they provide the most efficient solution to providing system security; and
- provide a clearly delineated set of responsibilities for efficient decision making.

In developing the EFCS governance framework, the Commission considered:

- **The rationale for the EFCS governance framework:** the materiality of underlying issues.
- **National and regional scheme development:** An EFCS should be nationally coordinated, but must also reflect the characteristics of individual regions.
- **EFCS purpose:** the purpose of EFCS, including how the EFCS Objective will guide AEMO and the Reliability Panel.
- **Delineation of responsibilities:** the key functions within the EFCS governance framework and how these should be distributed amongst various market bodies.
- **Over-frequency schemes:** the rationale for development of over-frequency schemes and what principles should be followed in overall design of these schemes.
- **New technology:** allowing for new technologies to be used in an EFCS, where these enable the most efficient system security solutions.
- **Cost recovery:** the processes for recovery of NSP costs in implementing an EFCS.
- **Frequency operating standards**: subsequent review of the FOS by the Reliability Panel.

3.4.1 Rationale for the EFCS governance framework

The NER currently set out a framework for load shedding that utilises localised, frequency sensing relays with pre-set frequency triggers.[69] Historically, these UFLS arrangements have been generally effective to limit the consequences of most non-credible contingency events.[70]

However, power system conditions are changing rapidly. The speed at which the power system frequency can change is increasing in some regions. There is also increased penetration of DER in distribution networks. In combination, these two factors may make UFLS arrangements that utilise only localised, pre-set frequency sensing relays, less effective.

Changes in demand and the generation mix, as well as increases in the export capability of interconnectors in some regions, also means that over-frequency events are becoming increasingly possible, with greater potential consequences. However, the existing frameworks do not provide an explicit framework for the emergency management of over-frequency events.

An enhanced EFCS governance framework will help to address these issues. These frameworks will allow for AEMO and other market participants to make use of all potential technologies and solutions, where these new technologies will provide the most efficient option to improve system security. These frameworks will also enable schemes to limit the consequences of over-frequency events, where this is required.

3.4.2 National and regional scheme development and design

The Commission's EFCS governance framework will support a nationally consistent and coordinated approach to emergency frequency control.

Role of jurisdictions

Jurisdictions will retain their current role in providing AEMO with schedules that establish the priority orders of sensitive loads and other loads. These arrangements are currently set out in the NER and require JSSCs to provide AEMO with schedules that:[71]

- describe the sensitive loads in the jurisdiction and the priority order of those loads over other loads specified in the schedule, including those loads for which the approval of the JSSC must be obtained by AEMO before it can interrupt supply to, or prevent reconnection of, the load; and
- sets out the order in which loads other than sensitive loads may be shed by AEMO for the purposes of load shedding.

69 These relay settings trigger and cause circuit breakers to open when they sense the frequency has dropped below a given threshold. They are pre-set in the sense that they cannot be changed in real time.

70 The Commission notes that existing schemes have not always worked effectively. Since NEM start, UFLS has twice been unable to prevent major non-credible contingencies leading to a black system events: in the North Queensland sub-network on 22 January 2009 and in the South Australian region on 28 September 2016.

71 NER clause 4.3.2(f).

The draft rule makes no changes to these arrangements and the JSSC will retain its function in setting the priority order of loads for an under-frequency scheme. The draft rule requires AEMO to set out the manner in which loads will be shed for an under-frequency scheme in its EFCS implementation guideline, having regard to the schedules provided by the JSSC under NER clause 4.3.2(f).

Emergency frequency control schemes will be designed in a coordinated manner across the NEM

The EFCS governance frameworks are designed to support a single scheme that operates in a coordinated and effective manner across the NEM.

Under current arrangements, AEMO does this by coordinating relay settings of UFLS arrangements across the NEM regions, with the aim of shedding load in an even manner across jurisdictions following a major disturbance.[72]

AEMO will continue to take a coordinated approach when developing an EFCS proposal.

The Commission recognises that this coordination process may be more complex, given the potential use of new technologies such as special protection schemes or a smart, centrally controlled system. The EFCS governance framework will require these issues to be clearly defined and explored during the development and design process.

Existing UFLS arrangements may require some adaptation to be incorporated into any EFCS proposed by AEMO. For example, AEMO may need to recalibrate settings on existing relays so they continue to operate in a coordinated manner with any new assets built as part of an EFCS. AEMO will coordinate and incorporate these existing mechanisms as necessary in its development of an EFCS proposal.

The final rule will therefore include any transitional arrangements necessary to recognise existing UFLS arrangements and their incorporation into an EFCS. AEMO will not be required to propose a redesign of these existing mechanisms, unless it considers this necessary to coordinate and incorporate them into the broader EFCS design.[73]

Schemes should also reflect the needs of individual regions

An EFCS should be designed on a national, coordinated basis. However, it may also need to reflect specific issues or needs in a region. For example, for those regions where separation from the rest of the NEM could reasonably occur, , AEMO may need to develop the EFCS so that it can also operate in an "islanded" mode within that region.[74] This will be accounted for in AEMO's development of an EFCS proposal, in the Reliability Panel's development of an EFCS standard, and in AEMO's functional design of the scheme with regional NSPs.

72 See AEMO Power System Security Standards for more information.

73 These transitional rules have not been included in the draft rule as they will need to reflect the finalised policy positions developed in the final rule as made.

74 When a region separates from the rest of the NEM, it loses any inertia provided by the rest of the interconnected system. This means that following a separation event, the islanded region may face more severe operating conditions, including faster RoCoF.

NSPs will also continue to develop emergency control schemes to meet their obligations under NER clause S5.1.8. As discussed in section 1.2.3, these schemes are typically designed to address localised voltage and other stability issues, or to prevent overload and tripping of specific assets following a non-credible contingency. They are separate to, and are not themselves, emergency frequency control services.[75]

The draft rule therefore requires NSPs to continue to develop these schemes to address localised issues.

3.4.3 Purpose of emergency frequency control schemes

As discussed in section 3.3.2, the draft rule contains the following EFCS Objective:

> "The objective for *emergency frequency control schemes* is for these schemes to be available and in operation to the extent appropriate having regard to the *national electricity objective,* to prevent or arrest *cascading outages, major supply disruptions* and uncontrolled increases or decreases in *frequency* (alone or in combination)."

The EFCS Objective's purpose is to provide both AEMO and the Reliability Panel with high level guidance to inform the development of an EFCS proposal and EFCS standard.

The Commission considered the following matters in developing this objective.

Purpose of the EFCS Objective

The purpose of the EFCS Objective is to provide guidance to both AEMO and the Reliability Panel:

- For AEMO, it provides guidance on when to prepare an EFCS proposal.
- For the Reliability Panel, it provides guidance on the determination of the EFCS standard.

The Reliability Panel will be guided by the EFCS Objective when assessing trade-offs between the capability of an EFCS to prevent a major supply disruption, and the costs of providing that capability. The Reliability Panel will make these trade-offs in light of the NEO, giving consideration to the long term interests of consumers, in terms of the efficient operation, use and investment in electricity services.

AEMO will also be guided by the EFCS Objective. The draft rule requires AEMO to consider, as part of meeting the power system security principles, whether there are an adequate EFCS available and in service to meet the EFCS Objective. Where this is no longer the case, AEMO will develop an EFCS proposal for assessment by the Reliability Panel.

75 Although by acting to prevent instabilities in the system, these schemes can act to prevent localised system collapses that could result in a frequency disturbance.

Arrest or prevent cascading outages, major supply disruptions and uncontrolled increases or decreases in frequency (alone or in combination)

There are three main components related to the function of an EFCS as defined in this part of the EFCS Objective:

- **Uncontrolled increase or decrease in frequency (alone or in combination):** An EFCS may contain an over-frequency scheme (to arrest an increase in frequency) and / or an under-frequency scheme (to arrest a decrease in frequency). The EFCS should act to dampen movements of frequency in either direction, where they may occur in combination.[76] As such, these components should be designed to act in coordination.
- **Arrest or prevent:** Existing UFLS arrangements utilise relays that are triggered by a fall in frequency. As such, these arrangements can only act to arrest a fall in frequency once this fall in frequency has already begun. Different technologies, such as special protection schemes, are not triggered by a change in frequency. Instead, these technologies may allow for load to be shed in response to a specific event, prior to any major increase or decrease in frequency.[77] The EFCS Objective therefore refers to preventing, as well as arresting, a change in frequency.
- **Cascading outages, major supply disruptions:** Ultimately, an EFCS is the last line of defence to stop the power system from collapsing to a black state following a major disturbance. However, it may also address less severe events, such as preventing a major supply disruption from getting any worse, through a cascading outage.[78] The Commission has chosen this wording in the EFCS Objective to reflect the fact that an EFCS can be used to address events of different severity.

3.4.4 Delineation of responsibilities

The Commission has proposed an EFCS governance framework that clearly delineates between the proposal, determination and design stages of developing an EFCS. These functions have been appointed on the basis of the functions, expertise and experience of the differed market bodies.

This delineation allows for the development of a robust EFCS adapted to changing power system conditions. It sets out the following responsibilities between jurisdictions, AEMO and the Reliability Panel.

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76 A major power system disturbance may result in sudden increases and decreases in frequency in rapid succession, reflecting fluctuations in the power system. An EFCS must be able to dampen these extreme swings in frequency, by combining load and generation shedding in a coordinated manner.

77 These special protection schemes use sensors to detect specific events (such as breakers opening on a specific transmission line) and send a signal via a devoted communications system to circuit breakers that shed a designated load. In effect, these schemes can act to shed load before a significant drop in frequency occurs across the system.

78 The NER define a major supply disruption as "the unplanned absence of *voltage* on a part of the *transmission system* affecting one or more *power stations* and which leads to a loss of supply to one or more *loads*. The Commission notes that this term includes both relatively minor and more severe incidents.

Jurisdictions determine priority order of loads

As discussed in section 3.4.2, jurisdictions will continue to be responsible for establishing the priority order of sensitive loads and other loads.

AEMO proposes and designs EFCS

As power system operator, AEMO is best positioned to identify power system issues as they arise across the NEM, including issues that may have significant impacts on the management of frequency.

AEMO is therefore the appropriate market body to initiate the process of EFCS development. However, this should not preclude other parties from identifying the need for changes to the EFCS to AEMO. AEMO will also be required to engage with relevant network businesses when developing the EFCS proposal.

AEMO is also best placed to provide the Reliability Panel with technical support in developing the EFCS standard. Its technical expertise and operator function give it the appropriate perspective to coordinate the design of a nationally consistent EFCS that can also address specific issues in each region.

Reliability Panel undertakes a cost benefit assessment

Historically, emergency frequency control has been provided through relatively low cost assets, mainly frequency sensing relays. These have provided a level of scheme capability adequate to limit the consequences of most non-credible contingency events.

These UFLS arrangements may no longer be effective, given the kinds of changes currently underway in the power system. In future, an EFCS may need to deal with more extreme conditions, requiring significantly greater scheme capabilities.[79] While new technologies may provide these increased capabilities, they may also add to the cost of an EFCS.

A rigorous cost benefit assessment process is therefore needed to deliver an EFCS with the necessary capability, at an efficient cost. This cost benefit assessment should occur early on in the process, to allow for assessment of the full range of potential scheme capabilities and costs.

The draft rule allocates this responsibility to the Reliability Panel. In undertaking this cost benefit assessment, the Reliability Panel may consider a range of potential scheme capabilities and associated costs. Its final decision will be based on assessing the trade-offs between the benefits to consumers of additional scheme capability, against the costs of providing that additional capability.

The Reliability Panel is the appropriate body to undertake this cost benefit assessment of an EFCS. Its existing functions already include assessing economic trade-offs to determine standards for the NEM, such as the System Restart Standard and the Frequency Operating Standards, as well as making recommendations for the Reliability Standard. Determination of the EFCS standard is consistent with these existing functions.

79 Such as the ability to withstand faster RoCoF, or to dynamically sense changes in load across distribution networks.

Reliability Panel determines an EFCS standard

The output of the Reliability Panel's cost benefit assessment will be an EFCS standard. This standard will set out the high level capabilities that the EFCS should be capable of delivering.

In developing this standard, the Reliability Panel may consider the information provided by AEMO, including the range of potential scheme capabilities and the estimated cost of delivering these capabilities. The Reliability Panel may also consider any other information it considers relevant. This information will be assessed against the EFCS Objective. The Commission expects that in determining the standard, the Reliability Panel will exercise its judgement to identify what it considers to be an optimal trade-off between capability and cost.

Importantly, the Reliability Panel's role is not to approve a specific proposed EFCS design. Instead, it will consider information on scheme capabilities and costs, in order to develop an EFCS standard. This EFCS standard then forms a design target to which AEMO develops its detailed EFCS design specifications.

3.4.5 Over-frequency schemes

In developing a framework for over-frequency schemes, the Commission has considered the following issues:

- Rationale for the development of over-frequency schemes.
- Manner in which generators will be shed.
- Market impact on generators.
- Responsibility for implementation.

Rationale for the development of over-frequency schemes

The Commission considers that over-frequency events could have increasingly material impacts on power system frequency.

Regions with limited interconnection to the rest of the NEM may be particularly vulnerable to an over-frequency event.

This is because of the potential consequences of an interconnector trip that results in the separation of the region from the rest of the NEM. If this trip occurs while the interconnector is at full export capacity, this could result in a major supply and demand imbalance within the region. This could in turn cause frequency to rise very rapidly, potentially tripping generation in the region and causing a cascading outage and potentially a black system.[80]

80 The rate at which frequency changes is related to the size of a contingency event and the level of inertia in a system. A large contingency with a small amount of inertia in a region could result in a very fast positive RoCoF, which could in turn cause generators in the region to trip, resulting in a rapid frequency drop. This may occur too rapidly for existing UFLS relays to act.

Whether this scenario occurs depends on actual patterns of demand and generation dispatch in a region, including the following:

- **Ratio of domestic demand to potential export flow:** The lower this ratio, the greater the risk that the trip of a fully loaded exporting interconnector will result in a large supply / demand imbalance in the region and trigger a rapid rate of frequency increase.[81]
- **Ratio of domestic generation and demand:** The higher this ratio, the greater the possibility that the region will be exporting power to the rest of the NEM at any given time.[82] This is particularly the case if there are large volumes of low to zero variable cost generation in a region, as these generators will seek to be dispatched whenever their relevant fuel source is available.
- **Inertia in the region:** In regions with low levels of domestic inertia, tripping of a fully loaded exporting interconnector may result in high levels of RoCoF in the region. This could trigger tripping of generators in the region.

Over-frequency schemes may therefore be more valuable in those regions with a greater chance of separation. The Commission notes that such mechanisms already exist to limit the consequences of over-frequency in Tasmania, while in South Australia ElectraNet and AEMO are currently working to establish an over-frequency scheme.[83]

As discussed in section 3.4.2, EFCS design may need to reflect the specifics of individual regions. This will include consideration of whether an over-frequency scheme is likely to be particularly necessary in any particular region.

Some stakeholders questioned whether an over-frequency scheme was warranted. The CEC suggested that instead of tripping units, wind farms can instead offer fast ramping response to an over-frequency event.

The Commission acknowledges that wind farms may be capable of offering fast response services. If these services are sufficiently fast, AEMO and NSPs may incorporate them into the design of an over-frequency EFCS. Furthermore, the Commission is also considering the introduction of fast frequency response (FFR) services through its System Security Market Frameworks review. It may be that wind generators can offer a ramping response into FFR markets, rather than as an emergency frequency control mechanism.

The CEC also stated that AEMO already has powers to set generator responses to over-frequency events in performance standards and that there was therefore no need to introduce an over-frequency scheme.[84] However, these performance standards form part of the terms and conditions of existing connection agreements between generators and NSPs, and presumably were factored into the commercial terms of those

81 As an example, the recent upgrade of the Heywood interconnector between South Australia and Victoria will increase potential export flows from South Australia from 460MW to 650MW. Assuming an average level of demand of around 1300 MW for South Australia, the ratio of potential maximum export to average total demand increased from 35% to 50%

82 Subject to limitations including price in both regions and other factors such as fuel availability.

83 AEMO, *Future Power System Security program - Progress Report*, August 2016, p.32.

84 CEC, Consultation paper submission, p.2.

agreements. The NER cannot require changes to be made to existing connection agreements. It would not therefore be possible for an over-frequency scheme to be implemented through changes to these performance standards

Manner in which generators should be shed following an over-frequency event

Generators should be shed by an over-frequency scheme in order to firstly maintain system security, then reliability.

This differs to under-frequency schemes, where the order of load shedding is determined by the JSSC in its load shedding schedules.

JSSCs have no equivalent function in generation shedding. AEMO is therefore the appropriate body to make this decision, subject to guidance in the NER.

The draft rule requires AEMO to establish the manner in which generation will be shed that AEMO determines is best calculated to achieve the power system security principles in NER clause 4.2.6. AEMO may determine a sequence and settings that will shed generation in order to:

- restore the system to a *secure operating state*; and then to
- restore the system to a *reliable operating state*.

The Commission has considered the following issues in developing these principles:

- **The main purpose of shedding generation is to return the system to a secure operating state:** Generation is shed to limit the consequences of an over-frequency event, including the subsequent risk of uncontrolled generator tripping and frequency collapse. However, the type of generation shed will affect the ongoing security of the power system. For this reason, AEMO should shed generation in such a way that maximises system strength and system inertia following the relevant contingency event.[85]
- **Second to this, AEMO should consider the ongoing reliability of the system:** Different types of generation will be able to restart in different timeframes and recommence exporting power to the grid, following being shed by an over-frequency scheme. For example, most wind and solar generators and some gas/diesel peaking units are physically able to restart and recommence export relatively quickly after being shed. In contrast, some larger thermal units may take longer to restart due to physical limitations.[86]

Market impacts on generators

The Commission notes issues raised by some stakeholders regarding the impacts of an over-frequency scheme on generator revenues.

The CEC stated that introduction of an over-frequency scheme could provide negative investment signals for renewable energy investment. The CEC stated that the over-frequency scheme as proposed would be arbitrary and would not provide

85 More information is available at: AEMO, *Future Power System Security program - Progress Report*, August 2016.

86 For example, large coal thermal units may need to restart auxiliaries such as fans and conveyer belts, and take some hours to restart boilers.

compensation arrangements for semi-scheduled generators. It was also argued this would also reduce the value of frequency lower services.[87]

The Commission acknowledges that triggering of an over-frequency scheme may affect generator revenues. However, we consider that the materiality of this is limited as over-frequency events are very rare and an over-frequency scheme is likely to be triggered on an infrequent basis. In addition if an over-frequency scheme is able to arrest a frequency collapse and prevent a black system event from occurring, all generators will benefit by maintaining the ability to export power, once the emergency conditions have passed. As such, the Commission does not consider the presence of an over-frequency scheme will have material impacts on investment signals.

Furthermore, the Commission does not consider that generator shedding is a substitute for FCAS lower services. These services are used for the pre-contingency management of credible contingencies, as opposed to over-frequency schemes that will be used on an ex-post basis for limiting the consequences of protected or non-credible contingency events. The presence of an over-frequency scheme should not impact on the value or price of lower services.

Given these factors, the Commission does not consider any form of compensation is warranted for participation in an over-frequency scheme. Compliance with these schemes is necessary for the general maintenance of power system security. As all parties benefit equally from a secure system, all parties should be required to participate.

Responsibility for implementation

NSPs and generators will be able to jointly implement over-frequency EFCS. However, NSPs are ultimately responsible for ensuring that an over-frequency scheme has been implemented to meet the requirements established in AEMO's EFCS design specification.

NSPs have the required technical expertise and experience to implement these schemes. As discussed in section 3.4.2, NSPs already play a key role in existing UFLS arrangements, as well as in the development of intra-regional, localised emergency control schemes for the management of stability issues. NSPs also already face a direct obligation under the rules to cooperate and assist AEMO in maintaining power system security.[88] Finally, NSPs are also provided with limitations on liability for their performance of system security functions.[89]

NSPs should therefore bear the final responsibility to implement the functional design specifications for an over-frequency scheme as designed by AEMO.

87 CEC, Consultation paper submission, p.2.

88 NER clause 4.3.4(a).

89 Section 119(2) of the NEL applies to NSPs and excludes civil monetary liability for an act or omission in the performance or exercise, or purported performance or exercise, of a systems operation function or power (as prescribed in the regulations). The section does not apply to an act or omission done or made through negligence or bad faith. Civil monetary liability for negligence is capped. The amount of the cap is determined by the regulations.

However, in some cases, Generators may wish to install new equipment or change settings on existing equipment themselves, to allow for scheme implementation.[90] This may provide Generators with greater control over how their generation units are shed during an over-frequency event, potentially minimising impacts on this equipment.[91] This approach may be more efficient overall, if it utilises existing assets, rather than requiring NSPs to install new assets.

The new EFCS framework requires NSPs to identify opportunities for generators to install or adapt equipment to meet the over-frequency scheme component of the EFCS design specifications. Where an NSP has identified such an opportunity, it must negotiate in good faith with the Generator regarding modifications to be made and other changes necessary to the Generator's equipment so the NSP can meet its EFCS implementation obligations. Such negotiations will not affect the exercise of current rights under a connection agreement.

Importantly, where the Generator has negotiated with the NSP and installs equipment, or changes settings on existing equipment, final responsibility for scheme performance, and any associated liability, remains with the NSP.

The Commission recognises that not all Generators may wish to install equipment or change their plant settings to implement an over-frequency scheme. In these cases, NSPs will implement the EFCS design specifications.

3.4.6 New technology

There are a number of new technological solutions that could be used to deliver an EFCS.

As identified by various stakeholders, emergency frequency control could be provided by technological solutions such as special protection schemes or distributed energy resources.

The NER frameworks should be technologically neutral. They should facilitate the use of all technologies to provide emergency frequency control, where those technologies represent are the most efficient solution. This will be supported by a robust assessment process in the governance framework, to help minimise costs for consumers.

Technological solutions for emergency frequency control

Traditionally, UFLS arrangements have utilised a distributed network of "static" relays to disconnect load in response to changes in frequency.[92] While AEMO and NSPs are

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90 For example, Generators may be able to change settings on existing protection equipment that sits on the Generator's side of the connection point.

91 For example, the Commission understands that Generators may be able to install equipment, or change settings on existing equipment, to shed specific units at specific frequencies. This would allow the generator to maintain some export to the power system during an over-frequency event, rather than having all export curtailed.

92 Static in the sense that the settings of these relays cannot be changed in real time to reflect power system conditions.

working with these existing relays to improve their function, there is a limit to what they can achieve.[93]

New technologies may enable a range of new solutions for emergency frequency control. This includes technologies and solutions that are already available, as well as those that are emerging.

These could include centrally coordinated "adaptive" load shedding schemes, that can account in real time for changes in the power system. Other solutions may include special protection schemes, that shed load or generation in response to specific contingency events. Emerging solutions could utilise DER technologies including battery storage to provide more granular and adaptive load or generation shedding.

The draft rule facilitates the use of new technologies, where efficient

The draft rule is designed to allow for the use of all available technologies, where these technologies represent the most efficient solution for the provision of emergency frequency control. It does this through the following two key changes:

- removing any reference in the NER to facilitating load shedding through relays "initiated automatically by frequency".[94] These clauses could be read as requiring the use of specific technologies that are initiated by a change in frequency. This could preclude the use of technologies that shed load or generation in response to a specific event, rather than in response to the subsequent change in frequency; and
- referring to the concept of preventing rapid increases or decreases in frequency in the EFCS Objective. This will allow for the inclusion of SPS type technologies that can trip load or generation more quickly than existing schemes.

More generally, the EFCS governance framework, including AEMO's development of the EFCS proposal and the Reliability Panel's determination of the EFCS standard, will allow for an effective cost benefit assessment of the full range of technologies. This will facilitate the use of technologies where they represent the most efficient way to deliver emergency frequency control services at the lowest possible cost to consumers.

3.4.7 Cost recovery

In the rule change proposal, the proponent stated that NSPs should be able to recover the costs of implementing EFCS. The Commission was requested to consider how these costs can be recovered.

The Commission considers that existing mechanisms are sufficient to allow NSPs to recover the costs of implementing these schemes.

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93 For example, AEMO and ElectraNet have recently completed a review of the relays that facilitate load shedding in South Australia and have changed settings to account for increased RoCoF when South Australia is separated from the rest of the NEM. For more information see: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/FPSSP-Reports-and-Analysis.

94 NER clause 4.2.6(c) currently refers to "Adequate *load shedding* facilities initiated automatically by *frequency* conditions outside the *normal operating frequency excursion band* should be available and in service to restore the *power system* to a *satisfactory operating state* following significant multiple *contingency events*.

Any services provided by NSPs to meet the design specifications would meet the NER definition of prescribed services.[95] As such, these services would be automatically included in allowed revenue during the AER's regulatory determination for the NSP.

NSP's are also able to seek to recover costs incurred part way through a regulatory period.[96] NSPs may apply for these costs to be passed through under the pass through provisions if they were required to implement an EFCS during a regulatory period.

3.4.8 Changes to the FOS

The proponent and AEMO have both stated that there are some issues with the current FOS, particularly Part B(f) of the current FOS. This clause says that:[97]

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

This clause effectively requires AEMO to maintain the frequency of the power system for all possible multiple contingency events. AEMO has argued that it is not physically possible to meet this requirement for all multiple credible contingency events.[98]

The Reliability Panel is responsible for determining the FOS.

The Commission will issue a terms of reference to the Reliability Panel to review the FOS following completion of this rule change.

95 NER Chapter 10 describes a prescribed transmission service as "services that are required to be provided by a *Transmission Network Service Provider* under the rules, or in accordance with jurisdictional electricity legislation, to the extent such services relate to the provision of the services referred to in paragraph (a), including such of those services as are: (1) required by *AEMO* to be provided under the Rules, but excluding those acquired by *AEMO* under rule 3.11

96 NER clause 6A.6.9.

97 Reliability Panel, *Application of Frequency Operating Standards During Periods of Supply Scarcity - Appendix B, NEM Mainland Frequency Operating Standards*, April 2009, p.17.

98 The FOS define a multiple contingency event as "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*. Multiple contingency event is not defined in the NER, however a non-credible contingency event is defined in NER clause 4.2.3(e) as any event other than a credible contingency event. As noted in Chapter 1, a non-credible contingency event could include events such as the simultaneous tripping of two generators, to events such as the simultaneous and independent tripping of every generator in a region.

4 Protected events

Protected events are a proposed new sub-category of non-credible contingency event. These are events that are currently classified as a non-credible contingency but which could have significant consequences if addressed solely through load shedding. Their consequences can be limited through a combination of managing the system at all times through the use of FCAS and constraining generation dispatch, as well through some ex-post load shedding.

Managing the system at all times to limit the consequences of a plausible, high consequence event may be expensive. It is essential there is a robust governance framework in place to assess these protected events and to determine what costs should be incurred to limit their consequences.

4.1 Proponent's views

The proponent stated that the current NER and FOS do not provide AEMO with sufficient guidance regarding the nature of the contingency events for which it must maintain the frequency of the power system.

The proponent argued that under current definitions, AEMO is effectively required to maintain power system frequency for all potential multiple contingency events. It was argued that this is not a realistic requirement, as this could include highly improbable events for which it would be impossible to maintain frequency, such as the simultaneous trip of all generation in a region.

The proponent therefore suggested a new framework to allow for nomination of specific system events. AEMO would be responsible for limiting the consequences of these nominated events. This would include provisions in the NER to allow an independent body, such as the Reliability Panel, to nominate specific system events for which the FOS should be maintained.

The objective of these provisions would be to provide clarity as to which multiple contingency events should be addressed and to define acceptable levels of consequence in mitigating the most severe outcomes of the specific events.

4.2 Stakeholder views

Several submissions to the consultation paper supported the introduction of a new category of protected events.

RES supported the idea of a protected event category, noting that for the security of the network a broader range of risk events should be considered, as well as a review of those risk events that have been considered non-credible.[99] Hydro Tasmania also broadly supported the concept and considered that there was a need to for guidelines around establishing protected events so that only high risk events are addressed.[100]

99 RES, Consultation paper submission, p.3.

100 Hydro Tasmania, Consultation paper submission, p.1.

AEMO supported the concept of protected events and suggested that these events should recognise trade-offs between the possibility and consequences of the protected event occurring, and costs of operating the power system to mitigate the risk of a protected event.[101]

Energy Australia noted that while introducing this new category may be a low-cost way to mitigate risks due to abnormal system conditions, the cost-benefit assessment should consider the additional procedural complexity associated with introducing a new category.[102]

4.3 Protected events

How an event is classified determines what actions AEMO takes to limit its consequences.

The classification of protected event is designed to increase the range of tools available to AEMO to limit the consequences of specific events.

This section describes:

- how contingency events are classified and what this means for system operation; and
- the new protected event classification.

Section 4.4 then describes the governance framework the Commission has developed for the assessment and implementation of protected events.

4.3.1 Current arrangements for contingency event classification and system operation

As discussed in section 1.2.4 the NER allows AEMO to classify events as either credible or non-credible contingency events. This classification also defines the actions that AEMO takes to manage or limit the consequences of the event.

A credible contingency event is a contingency event the occurrence of which AEMO considers to be reasonably possible in the surrounding circumstances.[103] AEMO manages the power system at all times so that the frequency will remain within specific bands should the credible contingency occur. It does this through the ex-ante procurement of FCAS and constraining generation dispatch.

The consequences of non-credible contingencies are limited mainly through ex-post load shedding. For more likely non-credible contingencies, existing UFLS arrangements can usually arrest a frequency decline by shedding load in a controlled manner. However, the capability of load shedding is limited and may not be able to arrest a fall in frequency for more extreme non-credible contingency events.[104]

101 AEMO, Consultation paper submission, p.10.

102 Energy Australia, Consultation paper submission, p.3.

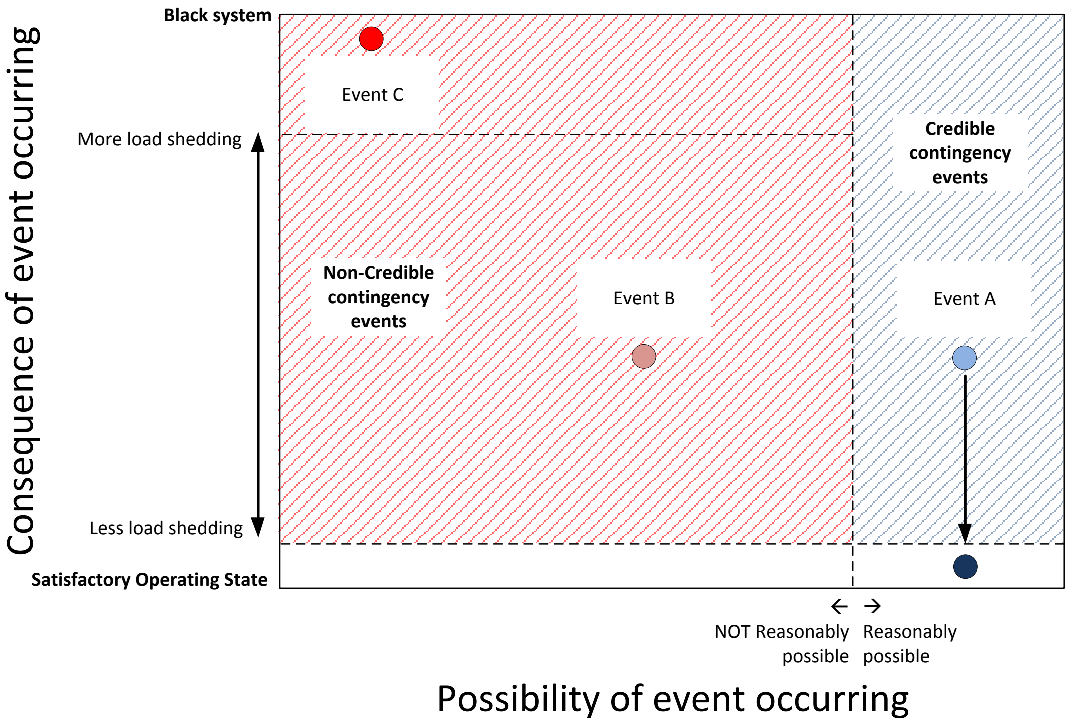
103 NER clause 4.3.2(b).

104 The larger the size of a contingency event, the more load that would need to be shed to arrest a frequency drop. However, once the amount of load shed from a power system passes a certain

Some examples of a credible and various non-credible contingencies are illustrated in Figure 4.1:

- **Event A: a credible contingency.** An event which AEMO considers is reasonably possible in the surrounding circumstances, such as a single generator tripping. AEMO manages the system at all times for this eventby using ex-ante solutions such as FCAS and system constraints. No load shedding occurs. This is represented by the downwards arrow, which reduces the potential consequences of the event so that the power system will be in a satisfactory operating state, if the event were to occur.
- **Event B: a moderate non-credible contingency.** An event which AEMO considers is not reasonably possible in the surrounding circumstances, the consequences of which are limited to some controlled load shedding. Such an event might include the simultaneous loss of two generators. Were it to occur, the consequences would be an amount of controlled load shedding, with the system returned to the normal operating band over a defined period.
- **Event C: an extreme non-credible contingency:** An event which AEMO considers is not reasonably possible in the surrounding circumstances, the consequences of which cannot be limited through load shedding. Such an event might include the simultaneous loss of all generators in a region. Were it to occur, interconnection to the region is likely to trip and load shedding would not be capable of preventing a black system in that region. However, this event is extremely unlikely to occur.

Figure 4.1 Credible and non-credible contingency events



point, voltage stability issues will result in the system collapsing. The capability of load shedding to arrest a drop in frequency is therefore limited by this physical constraint.

4.3.2 The protected event

The draft rule sets out a framework for a new category of contingency event classification, the protected event.

AEMO will be able to both manage the system at all times by using ex-ante solutions such as FCAS and constraining generation dispatch, as well as a pre-determined amount of load shedding, to limit the consequences of a protected event.

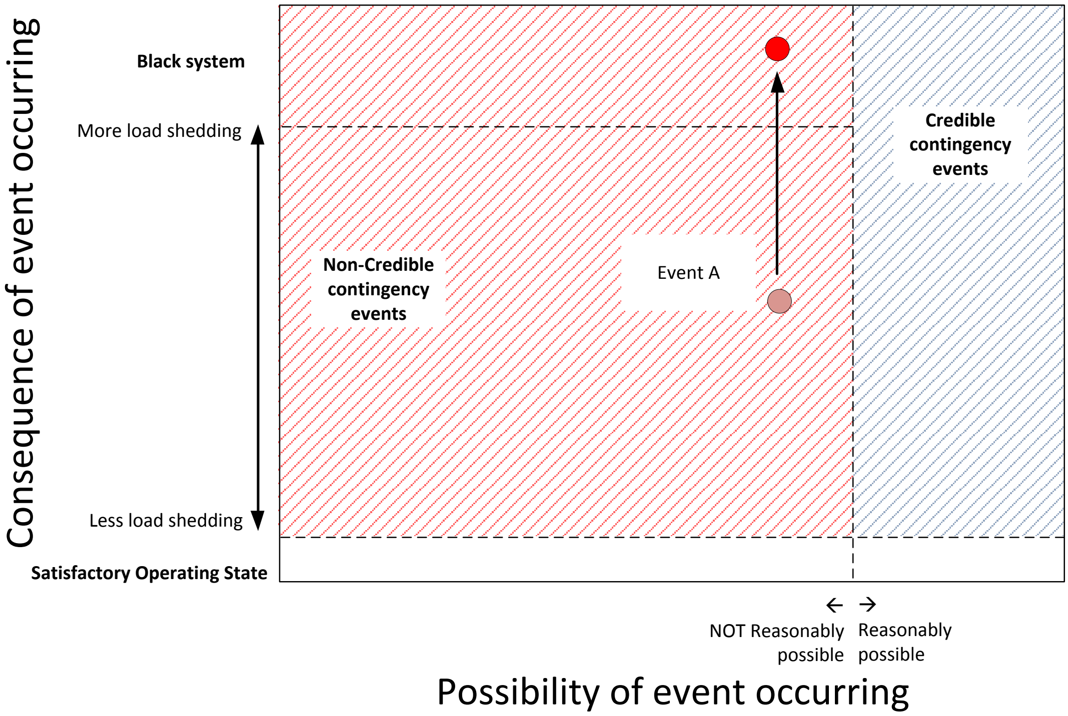
Introduction of the classification of protected event is intended to support more efficient outcomes for specific events, by allowing for the minimisation of the combined costs of ex-ante solutions and load shedding with the avoided economic costs of the event's consequences.

Limiting the consequences of credible and non-credible contingency events

As discussed above, AEMO manages the system at all times so that if a credible contingency were to occur, the frequency will remain within a defined frequency band and no load shedding will occur. For non-credible contingencies, the consequences of the event are limited through controlled load shedding.

AEMO can reclassify a non-credible contingency event to credible, where it considers the ***occurrence of the event*** has become more likely due to the existence of abnormal conditions. However, AEMO does not reclassify events where the ***potential consequence of the event*** have increased.[105] This is illustrated in Figure 4.2.

Figure 4.2 Increase in consequence



105 This is because NER clause 4.2.3A allows for AEMO to reclassify an event only when the occurrence of the event has become reasonably possible in the surrounding circumstances because of the existence of abnormal conditions in the power system.

In this scenario, Event A represents a non-credible contingency event, such as the loss of both circuits of a double circuit interconnector between two regions. The possibility that this event could occur has not changed.

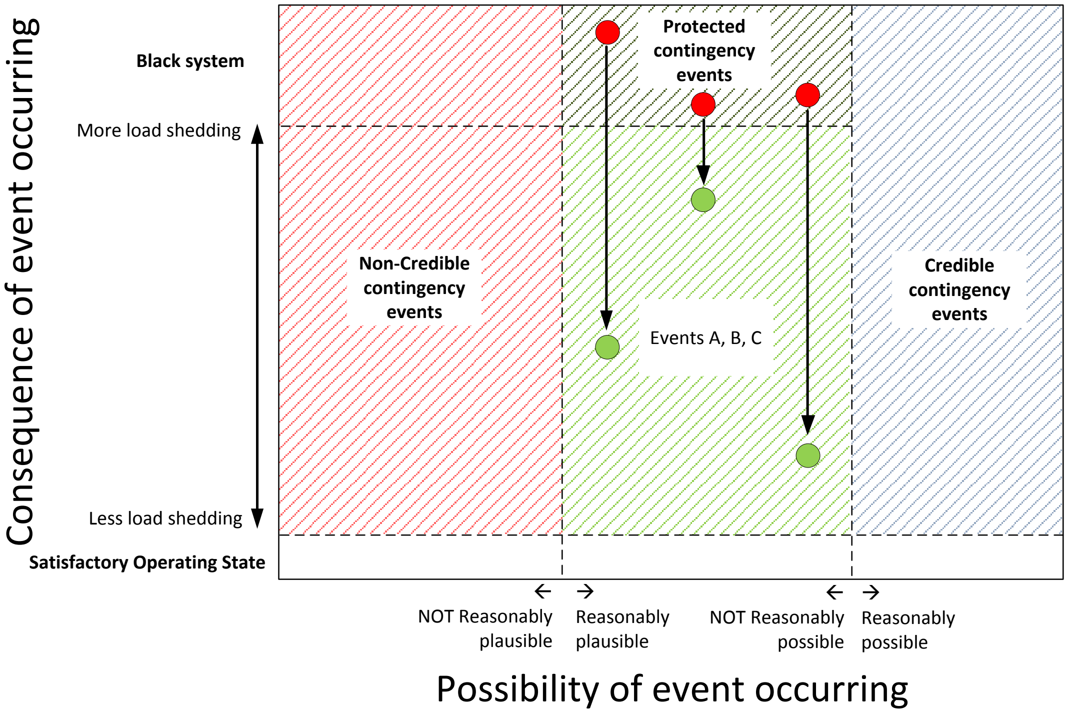
Historically, the consequences of this event were limited to some controlled load shedding, if it occurred. However, due to changes in power system conditions, its potential consequences have increased.[106] This means that if the event were to occur now, it would likely result in the power system collapsing to a black system condition.

Combined solutions to limit the consequences of these events

The protected events framework will allow for more efficient solutions to limit the consequences of these events.

For the specific contingency events that are defined as protected events, AEMO will be able to manage the system at all times by undertaking some ex-ante actions, such as procuring FCAS or constraining the system. This will mean that if the event occurs, existing load shedding schemes will have a better chance of operating and limiting the consequences of the event to some controlled load shedding.[107] This is illustrated in Figure 4.3.

Figure 4.3 Protected events



106 For example, as discussed in Chapter 3, increases in RoCoF and increased penetration of DER may reduce the effectiveness of existing load shedding schemes. In the example above, this could result in load shedding schemes being unable to arrest a drop in frequency following tripping of the interconnector, leading to a cascading failure and black system in the region.

107 For example, in event A in Figure 4.2 (the loss of an interconnector between two regions) the resultant RoCoF may have been too fast for under-frequency schemes to respond, resulting in a cascading tripping of generators and a black system in the region. However, by managing the system at all times by using some ex-ante solutions, such as applying system constraints to limit RoCoF, the system could be in a configuration so that following the event, under-frequency schemes would have enough time be able to respond in time to prevent the cascading failure.

Figure 4.3 illustrates how the consequences of a protected event could be limited:

- The consequences of the three contingency events A, B and C are such that, if they remained classified as non-credible contingency events and were addressed solely through ex-post load shedding, would likely result in the system collapsing to a black state.
- Once these events are defined as protected events, AEMO will be able to manage the system at all times by using some ex-ante solutions such as FCAS or applying constraints to generation dispatch, in combination with some ex-post load shedding. This means that if the events occurred, their immediate consequences would be limited to a given amount of controlled load shedding.
- The different arrow lengths represent different combinations of ex-ante solutions used and amounts of controlled load shedding allowed for each event. As discussed in more detail below, these combinations are defined by a post contingency operating state that the Reliability Panel will determine for each protected event:
  - For Events A and C, a "tighter" post contingency operating state has been determined by the Reliability Panel. This means that following the event, a relatively smaller amount of load shedding is allowed. To achieve this, AEMO is likely to have used more ex-ante services to limit the immediate consequences of the event.
  - For Event B, a "looser" post contingency operating state has been developed, with more controlled load shedding allowed.

4.3.3 Definition of the protected event and how it affects power system operation

To summarise, the core aspects of a protected event are:

- It is a sub-category of non-credible contingency events. Protected events are differentiated from non-credible contingency events in that AEMO is able to take some ex-ante actions to limit their potential consequences.
- It is an event that is reasonably ***plausible***. This means that while it is not reasonably likely to occur in the surrounding circumstances (and is therefore not a credible contingency event) it could still conceivably occur in the surrounding circumstances.
- It is an event with ***significant consequences***, where cascading outages resulting and/or a major supply disruption is possible if it were to occur.
- It is an event that can be reclassified as a credible contingency event, as per the arrangements established in NER clause 4.2.3A (see section 4.4.3 for more information on reclassification of protected events).
- AEMO will be able to use a combination of ex-ante solutions with some controlled load shedding, to limit the consequences of protected events.

- This will reflect a post-contingency operating state to be determined by the Reliability Panel. In determining this post contingency operating state, the Reliability Panel may include guidance on:
  - the frequency bands the system must meet following the event;
  - the time taken for the system to reach each frequency bands following the event; and
  - the extent of any load shedding allowed following the event.

4.3.4 Costs and benefits of a protected event

Introducing the category of the protected event will allow AEMO to operate the power system more efficiently. However, there are likely to be material costs associated with managing the system at all times to limit the consequences of these events, should they occur.

Allowing AEMO to use ex-ante solutions for protected events means that the costs of FCAS and system constraints will be incurred upfront, in order to limit the expected costs of the protected event, should it occur.

An efficient outcome will be achieved where the overall economic costs of a protected event are minimised, taking into account both actual costs and expected costs. This includes minimisation of the following:

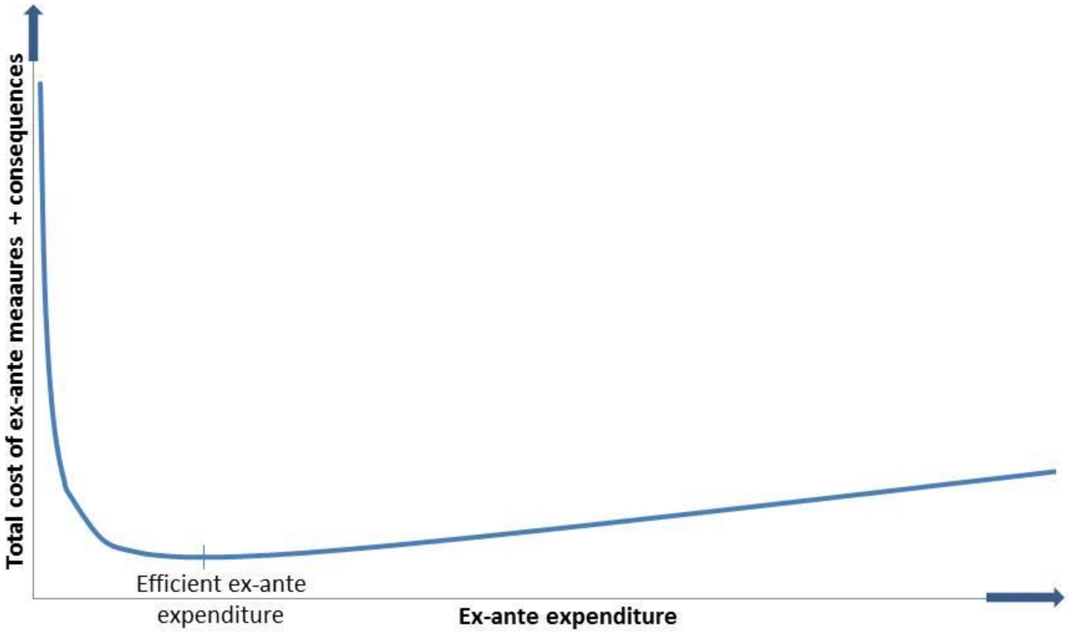
- the actual cost of ex-ante solutions, including the cost of procuring FCAS from generators, or the market costs associated with imposing constraints on the dispatch process. These are actual costs that will be incurred up-front on an ongoing basis, regardless of whether the protected event occurs;
- the cost of controlled load shedding, being the cost to the community of interruptions to electricity supply if under-frequency schemes are triggered. These are expected costs that would only be incurred if the protected event occurs; its value is a function of the possibility that the protected event will occur; and
- the avoided cost of the consequences of the protected event itself. This could include the costs of a cascading outage and/or a black system event. These are expected costs that would only be incurred if the protected event occurs; its value is a function of the possibility that the protected event will occur;

These various costs will be quantified differently and will be borne by different parties, according to current arrangements. For example, the costs of ex-ante solutions such as FCAS will be the $/MWh costs of procuring these services from FCAS markets and will be recovered from generators and market customers according to the arrangements set out in Chapter 3 of the NER. The costs of constraining generation dispatch may result in increased spot prices in a region and will be measured in $/MWh spot prices and ultimately consumer bills. Load shedding will result in social costs, being the effects of interruptions in supply of electricity to consumers. The distribution of these costs between parties will reflect operational decisions made by AEMO when it selects the solutions to be used to meet the post-contingency state described in section 4.4.

The concept of the minimisation of overall economic costs is illustrated in Figure 4.4.

This figure is illustrative only and is not based on any estimation of actual values. The shape of the curve would depend on the approaches used to estimating these values, such as the avoided costs of a black system, the value of lost load and the costs of ex-ante tools. Different values will result in different curves and different optimal outcomes.

Figure 4.4 Minimisation of combined cost of ex-ante tools and avoided consequences of event



The benefits of an avoided black system could be significant, given the extent of the potential economic costs of these events. However, the costs of procuring FCAS or constraining dispatch could also be significant, especially as these costs are incurred on an up-front, ongoing basis, regardless of whether the event in question occurs.

Balancing these different costs requires a careful cost benefit assessment. The draft rule requires the Reliability Panel to undertake this assessment, when it determines the post-contingency operating state for the protected event. This is discussed in more detail in section 4.4 below.

The Reliability Panel is the appropriate body to undertake this cost benefit assessment. Its existing functions already include assessing economic trade-offs to determine various NEM standards including the System Restart Standard and the Frequency Operating Standards, as well as making recommendations for the Reliability Standard. Assessing the costs and benefits of limiting the consequences of a protected event is consistent with this function.

4.4 Commission's considerations in developing protected events

The Commission has considered a number of issues in developing the classification of protected events:

- **Governance framework:** There may be significant costs associated with permanently operating the system in a way to limit the consequences of a protected event. A clear governance framework is needed to assess the efficiency of these costs.

- **Delineation of responsibilities:** A clear separation of responsibilities will deliver a governance framework that can effectively assess the costs and benefits of permanently operating the system to limit the consequences of protected events.
- **Consequential changes throughout the NER:** There are a number of parts of the NEM regulatory frameworks that may be affected by the introduction of the new category of protected events, including reclassification and stability requirements.

4.4.1 The protected events governance framework

The Commission has developed a governance framework for the identification, determination and implementation of a protected event.

This section describes the components of the protected events governance framework. Some of the matters considered by the Commission in developing this framework are discussed in following sections.

The proposed protected events governance framework is set out in Figure 4.5.

The main aspects of the protected events governance framework are as follows.

AEMO decides whether a non-credible contingency event is a protected event.

Under the draft rule, AEMO will be responsible for deciding whether a non-credible contingency event will be classified as a protected event.

The draft rule enables AEMO to make this decision where:

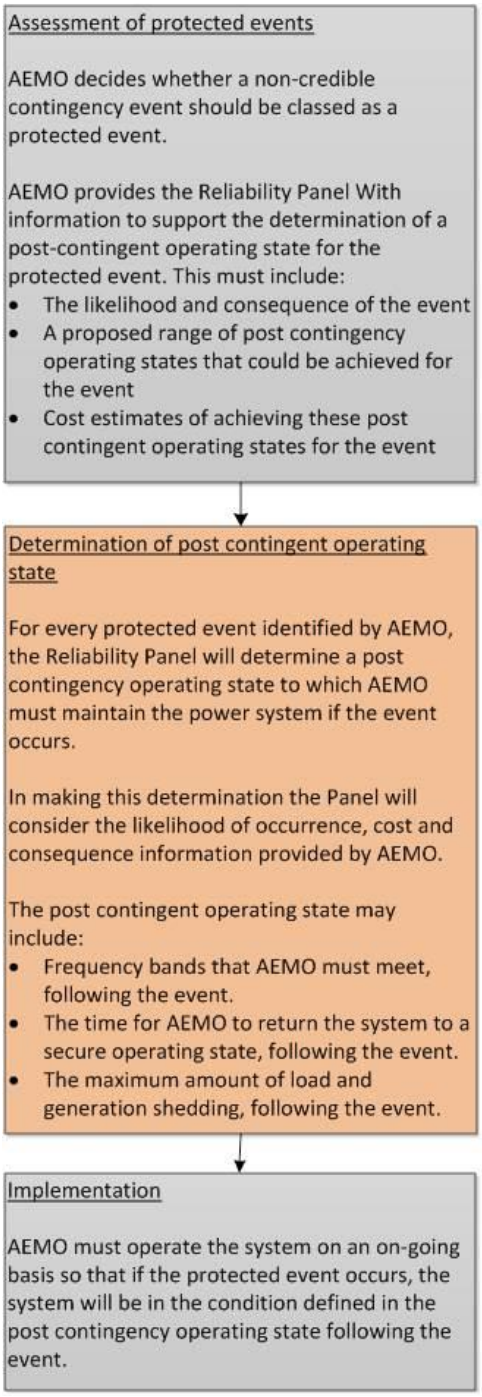
- the non-credible contingency event, while not considered to be reasonably possible in the surrounding circumstances, is reasonably plausible;
- if the non-credible contingency event were to occur, a cascading outage or a major supply disruption is at least reasonably likely to occur; and
- AEMO considers that these two factors considered together warrant the event being classified as a protected event.

Under the draft rule, when AEMO has decided that an event should be classified as a protected event, it will request the Reliability Panel to determine a post-contingency operating state for the protected event. AEMO's request must include the following information:

- an explanation of the nature of the non-credible contingency event and the consequences for the power system if the event were to occur;
- a range of proposed post-contingency operating states for that non-credible contingency event. Each potential post-contingency operating state may include information on:
  - times to return the power system to a secure operating state;
  - maximum levels of load shedding or generation shedding following the protected event;

- AEMO’s estimate of the cost of achieving each proposed post-contingency operating state including a description of the mechanisms that may be used to achieve the post-contingency operating state; and
- any other information AEMO considers reasonably necessary to assist the Reliability Panel in considering the request.

Figure 4.5 Protected events governance framework



Reliability Panel develops a post contingency operating state for the protected event

The Reliability Panel will be responsible for determining a post-contingency operating state for protected events, following a request by AEMO. This could include a post-contingency operating state that is different to any proposed by AEMO.

The Reliability Panel can only determine, or cancel the determination, of a post-contingency operating state for a protected event, when requested by AEMO.

For each protected event, the Reliability Panel would determine a post-contingency operating state applicable to the protected event. This is the target operating state of the power system following the occurrence of the protected event. The Reliability Panel's determination may also include the following matters:

- the time to return the power system to a secure operating state;
- any principles and guidelines to apply in respect of the protected event for the purposes of clause 4.2.6(b) in addition to or in place of the principles and guidelines published under clause 8.8.1(a)(2a);[108] and
- maximum levels of load shedding or generation shedding following the protected event.

The Reliability Panel must undertake its determination of any post-contingency operating state for a protected event through the rules consultation procedures.

AEMO implements measures to achieve the post contingency operating state, should the event occur

Once the Reliability Panel has determined a post contingency operating state (and any other matters), AEMO must operate the system accordingly.

This means that AEMO must be operating the system in such a way that if the protected event were to occur, its consequences would be limited to those defined in the post contingency operating state.

AEMO may achieve this through both managing the system at all times through ex-ante measures such as FCAS or constraining generation dispatch, or ex post measures such as load or generation shedding.

AEMO requests cancellation of a protected event

AEMO may request the Reliability Panel to cancel the determination of a post-contingency operating state if AEMO considers that the event should no longer be classified as a protected event. The Reliability Panel must cancel the determination at AEMO's request.

108 NER clause 4.2.6(b), which is one of the power system security principles, allows AEMO to take actions following a contingency event or a protected event in accordance with any principles and guidelines prepared under NER clause 8.8.1(a)(2a). NER clause 8.8.1(a)(2a) then includes in the functions of the Reliability Panel a responsibility to develop and publish principles and guidelines that determine how AEMO should maintain power system security while taking into account the costs and benefits to the extent practicable.

4.4.2 Delineation of responsibilities

The Commission has developed a protected events governance framework to clearly delineate between the identification of a protected event and the determination of the post-contingency operating state to apply to that protected event. These functions have been appointed on the basis of the current functions and expertise of the different market bodies.

AEMO has the relevant technical and operation expertise to determine when an event should be classified as a protected event

AEMO is the appropriate market body to decide whether an event should be classified as a protected event. It possesses the appropriate technical and operational knowledge to identify relevant issues as they arise.

AEMO will also be capable of preparing a complete and workable proposal to the Reliability Panel for the determination of a post-contingency operating state for each protected event. This will include developing proposed ranges of post contingency operating states and estimates of the costs to meet those states. This will assist the Reliability Panel in undertaking an effective cost-benefit assessment when determining the post-contingency operating state.

AEMO is also best placed to identify when an event should no longer be classified as a protected event. AEMO's technical and operational knowledge will allow it to determine when changes in power system conditions have reduced the potential consequence or possibility of the event.

The Reliability Panel is the appropriate body to determine the post-contingency operating state for the protected event

Determining a post-contingency operating state for a protected event is consistent with the Reliability Panel's existing functions. The Reliability Panel already undertakes similar cost benefit assessments when developing various NEM standards. In particular, the Reliability Panel already makes similar judgements and assesses economic trade-offs when determining the System Restart Standard or the Frequency Operating Standards, or when making recommendations for the level of the Reliability Standard and Settings.

The Reliability Panel also possesses the appropriate decision making abilities and experience. In particular, the Reliability Panel has the ability to exercise its judgement and make economic trade-offs between different factors, such as the cost of ex-ante solutions, the cost of lost load and the avoided costs of an event's consequences, in order to determine an efficient post-contingency operating state for each protected event.

The Reliability Panel will use information and technical expertise provided by AEMO when determining the post-contingency operating state. However, the Reliability Panel may also request information from other participants and from relevant experts, as it sees fit.

4.4.3 Consequential changes throughout the NER

There are a number of consequential changes that may need to made throughout the NER.

The first of these relates to the ability of AEMO to reclassify contingency events as credible contingency events. AEMO is able to reclassify a non-credible contingency event to a credible contingency event where it considers that is reasonably possible that the event will occur due to the presence of abnormal conditions. This reclassification process is therefore used on a temporary basis, with events reclassified back to non-credible once the abnormal conditions have passed.[109]

The draft rule allows AEMO to temporarily reclassify a protected event as a credible contingency event. This follows the current arrangements for reclassification. AEMO may reclassify a protected event as a credible contingency event where it considers that the existence of abnormal conditions make the occurrence of the event reasonably possible. Once AEMO considers that the abnormal conditions have passed and the occurrence of that event is no longer reasonably possible, AEMO can reclassify that event back to a protected event.

However, the draft rule does not allow AEMO to temporarily reclassify a non-credible event as a protected event. This can only occur through the process described above, where AEMO decides that a non-credible contingency event is a protected event and requests the Reliability Panel to determine a post-contingency operating state for that event.

Other consequential changes relate to a number of NER clauses for system stability, including:

- S.5.1a.3 System Stability;
- S.5.1a.4 Power frequency voltage;
- S5.1a.7 Voltage unbalance;
- S5.1.4 Magnitude of power frequency voltage; and
- S5.1.8 Stability.

AEMO has advised that these clauses should be amended to include reference to protected events, as appropriate. AEMO advises this is necessary so as to:

- maintain system stability following a protected event; and
- allow for specific technologies to be used for managing system frequency and stability, such as an SPS.

The Commission understands that these changes may impose some costs on NSPs through conformance with standards but that they are necessary to maintain system security for protected events.

109 NER clause 4.2.3A.

Abbreviations

AEMC or Commission	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
Commission	See AEMC
DER	distributed energy resources
EFCS	emergency frequency control scheme
FCAS	frequency control ancillary services
FOS	frequency operating standard
JSSC	jurisdictional system security coordinator
MCE	Ministerial Council on Energy
NEL	National Electricity Law
NEM	National Electricity Market
NERL	National Energy Retail Law
NGL	National Gas Law
NEO	National electricity objective
NERO	National energy retail objective
NGO	National gas objective
NSP	network service provider
RoCoF	rate of change of frequency
UFLS	under-frequency load shedding

A Summary of other issues raised

This appendix sets out the issues raised in the first round of consultation on this rule change request and the AEMC's response to each issue. If an issue raised in a submission has been discussed in the main body of this document, it has not been included in this table.

Stakeholder	Issue	AEMC Response
RES	Wind power, solar PV and battery energy storage can all provide responses to over frequency events more quickly than conventional generators and should be considered as part of ways to improve the effectiveness of an OFGS. Page 2 of Consultation paper submission.	AEMO will be able to consider all available technologies when developing an EFCS proposal and when developing the detailed EFCS functional design. This may include emergency frequency control provided by wind power, solar PV and battery storage.
ENA	The ENA stated that the Emergency frequency control scheme rule changes should include consideration of: • whether the schemes should also focus on a hybrid load perspective that includes solar photovoltaics and batteries, rather than conventional generation; • that current arrangements could be enhanced to cater for two-way interconnector flows with the potential for significant flow changes over relatively short intervals; • prioritising a coordinated control approach for DER; and • whether technology neutral rules adequately address the requirements of DER or storage options. Page 4 of Consultation paper submission.	AEMO will be able to consider all available technologies when developing an EFCS proposal and when developing the detailed EFCS functional design. This may include the solutions described by ENA.

Stakeholder	Issue	AEMC Response
ENA	Oversight of UFLS schemes should not be the sole responsibility of one party. One example would be the Victorian Electricity Emergency Committee – Technical Working Group. Page 4 of Consultation paper submission.	The Reliability Panel will be responsible for developing the EFCS standard. The Panel consists of members from industry and consumer groups. It will provide effective oversight for the development of these schemes. Jurisdictions will continue to be responsible for determining the order of load shedding.
ENA	S5.1.8 could be amended to provide TNSPs with explicit responsibility for managing change in frequency, including fast frequency response, for a defined set of non-credible contingency events. The economic efficiency by which TNSPs achieve such obligations for system strength outcomes would require regulatory oversight. Page 6 of Consultation paper submission.	S5.1.8 deals with stability issues rather than frequency issues. AEMO is better placed than TNSPs to develop an EFCS that is coordinated and consistent across the NEM.
SA Department of State Development	There is no predictable indication that there is an increasing risk of failure of a dual redundant connection between regions under normal operating conditions. Therefore the applicability of re-classification (under 4.2.3A NER) should be expanded to include the context of non-credible events causing a major disturbance that would result in cascading failure if not accounted for in the design of the emergency frequency control scheme. Page 6 of Consultation paper submission.	AEMO is currently able to reclassify events from non-credible to credible, where it considers that the event has become reasonably possible in the surrounding circumstances due to the presence of abnormal conditions. The draft rule also introduces the category of protected event, which will allow AEMO to identify specific events as protected events and request that the Reliability Panel develop a post-contingency operating state for those events. This will allow AEMO to both manage the system at all times by using ex-ante solutions such as FCAS and constraining generation dispatch and ex-post solutions to limit the consequences of those events.

Stakeholder	Issue	AEMC Response
SA Department of State Development	AEMO and the JSSC, in consultation, should have the ability to direct NSPs to invest in new technologies, in cases where the NSPs have not done so. This will allow AEMO to rely on both the load nominated for shedding and the suitability of mechanisms to shed the load when designing an emergency load shedding scheme. Page 7 of Consultation paper submission.	The new EFCS frameworks clearly allocate roles and responsibilities. This includes a requirement for NSPs to implement the functional design specifications developed by AEMO. NSP responsibilities are defined in the draft determination to commission, maintain, monitor, test, modify and report to AEMO in accordance with the EFCS implementation procedures and EFCS design specifications. These responsibilities are defined as a civil penalty provision. Any non-compliance with the provision may therefore result in enforcement action by the Australian Energy Regulator. The Commission considers that this framework establishes strong compliance obligations on NSPs and is consistent with existing arrangements. As such, any separate AEMO and JSSC oversight / direction mechanism is not required.

B Legal requirements under the NEL

This appendix sets out the relevant legal requirements under the NEL for the AEMC to make this draft rule determination.

B.1 Draft rule determination

In accordance with s. 99 of the NEL the Commission has made this draft rule determination in relation to the rule proposed by the South Australian Minister for Mineral Resources and Energy.

The Commission's reasons for making this draft rule determination are set out in section 2.4.

A copy of the draft rule is attached to and published with this draft rule determination. Its key features are described in sections 3.3 and 4.3.

B.2 Power to make the rule

The Commission is satisfied that the draft rule falls within the subject matter about which the Commission may make rules. The draft rule falls within s. 34 of the NEL as it relates to:

- the operation of the national electricity system for the purposes of the safety, security and reliability of that system; and
- the activities of persons (including registered participants) participating in the national electricity market or involved in the operation of the national electricity system.

Further, the draft Rule falls within the matters set out in schedule 1 to the NEL as it relates to:

- the operation of generating systems, transmission systems, distribution systems or other facilities;
- the augmentation of transmission systems and distribution systems; and
- the application of a rule applicable to network service providers, to regulated transmission system operators, or to AEMO in its capacity as a provider of transmission services.

B.3 Commission's considerations

In assessing the rule change request the Commission considered:

- it's powers under the NEL to make the rule;
- the rule change request;
- submissions received during first round consultation;
- the Commission's analysis as to the ways in which the proposed rule will or is likely to, contribute to the NEO; and

- the ongoing package of work being undertaken by the Commission in conjunction with AEMO related to System Security.

There is no relevant Ministerial Council on Energy (MCE) Statement of Policy Principles.

The Commission has not considered the revenue and pricing principles because the Commission considers that these are not relevant to this rule change request.

The Commission may only make a rule that has effect with respect to an adoptive jurisdiction if satisfied that the proposed rule is compatible with the proper performance of Australian Energy Market Operator (AEMO)'s declared network functions.[110] The draft Rule is compatible with the performance of those functions as it leaves those functions unchanged.

B.4 Northern Territory considerations

The National Electricity (Northern Territory) (National Uniform Legislation) Act 2015 allows for an expanded definition of the national electricity system in the context of the application of the NEO to rules made in respect of the Northern Territory, as well as providing the Commission with the ability to make a differential rule that varies in its terms between the national electricity system and the Northern Territory's local electricity system.

The Commission has considered whether a differential rule is required for the Northern Territory electricity service providers and concluded that it is not required in this instance. This is because the provisions of the draft rule either do not currently apply in the Northern Territory or, for the new Chapter 10 definitions, apply to parts of the rules that have not yet been adopted in the Northern Territory.

B.5 Civil penalties

The Commission's draft rule introduces new clause 4.3.4(ba) of NER. The Commission will be recommending to the COAG Energy Council that this clause be classified as a civil penalty provision under Schedule 1 of the National Electricity (South Australia) Regulations.

The Commission considers that rule 4.3.4(ba) should classified as a civil penalty provision because a breach of this provision could have a material impact on power system security, and reliability, and classification of this provision as a civil penalty will encourage compliance with it by NSPs

The Commission does not consider any other provisions of the draft rule should be classified as civil penalty provisions.

The Commission cannot create new civil penalty provisions. However, it may recommend to the COAG Energy Council that new or existing provisions of the NER classified as civil penalty provisions.

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110 Section 91(8) of the NEL.