AEMC

RULE

Australian Energy Market Commission

DRAFT RULE DETERMINATION

NATIONAL ELECTRICITY AMENDMENT (MANDATORY PRIMARY FREQUENCY RESPONSE) RULE 2020

PROPONENTS
AEMO
Dr. Peter Sokolowski

19 DECEMBER 2019

INQUIRIES

Australian Energy Market Commission
PO Box A2449
Sydney South NSW 1235

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

Reference: ERC0274

CITATION

AEMC, Mandatory primary frequency response, Draft rule determination, 19 December 2019

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.

EXECUTIVE SUMMARY

1 The Australian Energy Market Commission (AEMC or Commission) has made a more preferable draft rule to require all scheduled and semi-scheduled generators in the National Electricity Market (NEM) to support the secure operation of the power system by responding automatically to changes in power system frequency. An increase in the provision of primary frequency response (PFR) from generators will improve the security of the national electricity system for the benefits of consumers and will give the Australian Energy Market Operator (AEMO) greater confidence that it is maintaining the power system in a secure operating state.

2 The Commission concluded in its 2018 *Frequency control frameworks review* that frequency performance under normal operating conditions had been declining in recent times and that changes to the existing frameworks were required to support effective frequency control in the national electricity system. The gradual shift toward more variable sources of electricity generation and consumption, and difficulties in predicting this variability, increases the potential for imbalances between supply and demand that can cause frequency disturbances. At the same time, generators who are not enabled to provide frequency control through the ancillary service markets have been decreasing or removing their responsiveness to correct frequency deviations on a voluntary basis.

3 Historically in the NEM, only synchronous generators, such as coal, gas and hydro, have provided PFR. However, asynchronous generators such as wind, batteries and solar PV, can also provide PFR. As these technologies form an increasingly large proportion of the supply mix, it is important that any PFR arrangements consider the capabilities and performance of these newer technologies adequately.

4 The Commission considers that a rule that introduces a mandatory requirement for generators to activate an existing capability to provide PFR is likely to address the immediate need identified by AEMO for improved frequency control in the NEM. However, the Commission recognises that a mandatory requirement for narrow band PFR is not a complete solution and, on its own, will not incentivise the provision of primary frequency response . The Commission considers that further work needs to be done to understand the power system requirements for maintaining good frequency control. This future work will also consider the appropriateness of the mandatory requirement for narrow band PFR and other alternative and complementary measures, including the potential for new market and incentive-based mechanisms for frequency control.

5 This approach is consistent with the frequency control work plan that was agreed as part of the Commission's 2018 *Frequency control frameworks review* which identified a need to reform the frequency control arrangements in the NEM to keep pace with technological change. The Commission's final report for the review recommended the implementation of interim arrangements, if required, along with the development of frameworks to incentivise the provision of sufficient PFR over the long term to support good frequency performance during normal operation.

6 The draft rule includes a sunset on the mandatory PFR requirement three years in the future

on 4 June 2023. The inclusion of the sunset demonstrates the Commission's commitment to the implementation of further reforms prior to June 2023 to appropriately value and reward the provision of frequency control services. This draft determination includes an updated draft frequency control work plan developed in collaboration with AEMO, which sets out a pathway to the development of future arrangements to appropriately incentivise and reward frequency control in the NEM. The AEMC will continue to work with the ESB, AEMO and the AER on these matters.

7 The draft rule

8 The Commission's draft rule has been made with respect to two rule change requests; one received from AEMO and another from Dr. Peter Sokolowski. Each of these requests proposed to mandate that all capable scheduled and semi-scheduled generators be operated to respond to changes in the locally measured power system frequency, albeit through different proposed changes to the National Electricity Rules (NER).

9 As the scope of these two rule change requests cover similar and related matters, the Commission has determined to consolidate these requests and publish a single draft determination and draft rule.

10 The draft rule places an obligation on all scheduled and semi-scheduled generators, who have received a dispatch instruction to generate to a volume greater than 0 MW, to operate their plant in accordance with the performance parameters set out in the *Primary frequency response requirements* (PFRR) as applicable to that plant. AEMO is responsible for system security and the operation of the power system and so would also be responsible for the development of the PFRR, in consultation with market participants.

11 The draft rule introduces a new *primary frequency control band* of 49.985 Hz to 50.015 Hz, which sets a lower bound on the deadband to which individual generators must comply under the conditions of the PFRR. The Commission considers that the *primary frequency control band* is a key variable associated with the draft rule, which has implications for both system operation and the operation of the markets for electricity and ancillary services in the NEM. In the absence of a clearly defined frequency performance standard in the frequency operating standards, the Commission has determined that the lower bound for the *primary frequency control band* be specified in the NER, and not subject to full discretion by AEMO in the PFRR.

12 The Commission considers this immediate change to the NER is justified by the need to improve and maintain the security and resilience of the national electricity system to meet AEMO's concerns. AEMO's view is that all of the generation fleet needs to provide primary frequency response in order to be effective in managing system security.

13 The Commission has also specified in the draft rule that the PFRR cannot require generators to maintain additional headroom or stored energy for the purposes of providing frequency

response in accordance with the requirements of the PFRR.[1] The Commission acknowledges that AEMO does not propose to include a requirement in the PFRR that generators maintain headroom as part of its proposed rule. However, the PFRR is subject to change, and any future obligation which results in a large cross-section of the generating fleet maintaining headroom would likely impose substantial costs on generators that outweigh the additional benefits this might provide to the security of the power system. This aspect of the draft rule will provide greater clarity and certainty to generators and will limit the likelihood of substantial unwarranted costs being incurred by generators in the future.

14 Exemptions

15 The draft rule includes a requirement for AEMO to develop and publish the PFRR to specify the performance parameters that apply to generators in respect of the provision of PFR. The draft rule requires that the PFRR includes provision for generators to request, and AEMO approve, an exemption or variation from the requirements specified by AEMO in the PFRR applicable to their generating system. The draft rule sets out a series of principles to guide AEMO in considering any such requests.

16 The Commission expects that the costs for existing generators to meet the performance parameters for PFR will vary. Some plant connected prior to 5 October 2018 may require significant plant upgrades and control system tuning in order to provide PFR in accordance with the performance parameters.[2] The exemption framework introduces a degree of flexibility that avoids excessive compliance costs for eligible generation plant while still delivering on AEMO's system security and frequency control objectives.

17 Implementation

18 The commencement date for the rule is 4 June 2020. The transitional rules require that AEMO prepare an interim PFRR to apply from the commencement date. The interim PFRR will document AEMO's process for coordinating changes to generation plant associated with the activation of the frequency response mode. This process includes a requirement for AEMO, in coordination with each generator, to specify a date, following the commencement date of the rule, by which time the generator must comply with the performance parameters set out in the PFRR. AEMO would be required to consult with stakeholders prior to publishing the interim PFRR by the commencement date of the rule.

19 AEMO's proposed rule included transitional arrangements for generators to submit a claim for reimbursement of costs associated with plant upgrades to become compliant with the PFRR. The Commission's draft rule does not include any transitional arrangements for affected

1 Available headroom for frequency response refers to the capacity for a generator to raise its generation output in response to a drop in system frequency. It is dependent on the generating level of the plant based on market dispatch along with energy source availability and plant operating limits. Unless curtailed due to system constraints, semi-scheduled generators such as solar and wind power stations typically do not maintain stored energy or headroom, as their generation output is limited by the energy availability of the wind or sun. On the other hand, scheduled generators including thermal, hydro and batteries typically operate with some level of stored energy availability which varies by plant type. Scheduled generators maintain stored energy for a range of reasons, including maintaining a minimum ramp rate capability and in accordance with being enabled in the market for provision of frequency control ancillary services.

2 The 2018 *Generator technical performance standards* rule introduced changes to the NER that included a requirement for connecting generators to be capable of operating in a frequency response mode. This rule commenced on 5 October 2018. The Commission expects that most generators who connect to the NEM after 5 October 2018 will be capable of complying with the draft rule — *Mandatory primary frequency response*.

generators to be directly reimbursed for plant upgrade costs. Compensation is not typically provided to affected parties for the costs associated with complying with an amendment to the NER. Furthermore, the costs for plant upgrades and control system changes are expected to be relatively minor and manageable for most affected generators. Where the costs of plant upgrades would be more substantial, it is intended that a generator will be eligible for a full or partial exemption from the requirement which will avoid or reduce the upfront costs.

20 Sunset to the rule and forward work plan

21 In the context of the full range of solutions identified through the *Frequency control frameworks review* to improve frequency control during normal operation, the Commission considers that the mandatory PFR requirement is only acceptable in isolation for an interim period. The Commission is mindful of the costs that such a mechanism, on its own, would impose on generators. While a mandatory approach may be necessary in the interim in order to meet immediate system security needs, it would be preferable for this approach to be complemented by incentives and rewards for providing frequency response. Stakeholder submissions to the consultation paper expressed a broad support for the development of mechanisms that create efficient incentives for investment in and operation of plant to provide PFR. However, given the time needed to develop such arrangements, the Commission considers that it is not possible to implement an effective incentive arrangement at the same time as addressing the immediate system security needs.

22 Additionally, the Commission is aware of stakeholder concerns in relation to the potential for the mandatory PFR requirement to dampen the available incentives for providing frequency control through the markets for Frequency control ancillary services (FCAS). While AEMO has indicated that it does not intend to reduce the quantity of contingency reserve services that it procures as a consequence of this rule, it is expected that the mandatory PFR requirement will drive increased participation in the FCAS markets, which will increase competition and put downward pressure on prices for these services. The Commission recognises that the evolution of the FCAS markets has not kept pace with the system requirements for frequency control and that the implementation of mandatory PFR is now required to support the secure operation of the power system. The Commission considers that further work needs to be done to understand the power system requirements for maintaining good frequency control and to reform the existing frequency control frameworks to meet these needs now and in the future.

23 Therefore, the draft rule includes provision for a sunset after a period of three years. The sunset provision in the draft rule is a clear signal that the Commission is committed to developing incentive arrangements for primary frequency response prior to June 2023.

24 To reflect this commitment to the ongoing reform of the frequency control frameworks, the AEMC, in collaboration with AEMO, has developed a draft revised *Frequency control work plan*. The revised work plan is based on the plan published at the end of the *Frequency control frameworks review* in July 2018 and provides an update on progress to date on key actions along with an indication of the next steps in the reform pathway for frequency control frameworks in the NEM.

25 Once the immediate system security concerns are addressed, the ESB, AEMO, the AER and

the AEMC will be better placed, in terms of time frames and flexibility, to further develop new approaches to frequency control and PFR. The Commission considers that three years would afford the ESB and the market bodies adequate time to work collaboratively in determining arrangements that incentivise frequency control in the NEM.

26 The consideration and implementation of incentive arrangements will be considered through the assessment of AEMO's remaining rule change request, *Removal of disincentives to primary frequency response*. AEMO's rule change request identifies issues in the NER that relate to the existing incentive arrangements for market participants to help to control system frequency during normal operation. The Commission has extended the time frame for the publication of a draft determination with respect to this rule change request until September 2020, and will consult with stakeholders on the scope and direction for this rule change process in early 2020.

27 Consultation

28 The AEMC invites submissions on any aspect of this draft determination by 13 February 2020.

29 Stakeholder input on this draft determination will further inform the AEMC's analysis of the issues and the development of final rules, which will be reflected in a final determination in March 2020.

30 The AEMC also welcomes individual meetings with interested stakeholders. Those wishing to meet with the AEMC should contact Ben Hiron on (02) 8296 7855 or ben.hiron@aemc.gov.au.

CONTENTS

APPENDICES

TABLES

FIGURES

1 THE RULE CHANGE REQUESTS

1.1 The rule change requests

The Australian Energy Market Commission (AEMC or Commission) has made a draft rule that places an obligation on all scheduled and semi-scheduled generators to provide primary frequency response (PFR). The obligation to provide PFR must be met in accordance with technical criteria to be developed by the Australian Energy Market Operator (AEMO) and set out in its *Primary frequency response requirements* (PFRR) document. AEMO would be responsible for the development of the PFRR in consultation with market participants.

The Commission has made this draft rule based on advice from AEMO that this reform will meet the immediate system need for effective frequency control in the NEM. However, the Commission also considers that further reform will be needed in the future as the nature of primary frequency response capability in the NEM changes over time due to the changing generation mix, including the transition towards more variable and distributed forms of energy generation. As such, the draft rule includes a sunset period of three years to provide time to develop and implement an approach that achieves the system security objectives outlined by AEMO but does so in a way that also provides effective incentives for participants to provide primary frequency response.

The AEMC has received two rule change requests relating to primary frequency response in the NEM: one from AEMO and one from Dr. Peter Sokolowski.

- ERC0274 - *Mandatory primary frequency response*, submitted by AEMO on 16 August 2019,
- ERC0277 - *Primary frequency response requirement*, submitted by Dr. Peter Sokolowski on 30 May 2019.

Each of these rule change requests proposed changes to the National Electricity Rules (NER) to introduce a mandatory obligation for all scheduled and semi-scheduled generators in the National Electricity Market (NEM) to control power system frequency. The proposed requirement would require eligible generators to vary the power they deliver to the grid whenever the system frequency moves outside of narrow frequency band close to 50Hz. The rule change requests also propose a number of related changes to the regulatory arrangements that are intended to improve frequency control and system security in the national electricity system.

As the scope of these two rule change requests cover similar and related matters, the Commission has determined to consolidate these rule change requests under section 93 of the National Electricity Law (NEL) and publish a single draft determination and draft rule.

The AEMC also received a second rule change request from AEMO on 3 July 2019 which relates to incentive arrangements for the provision of primary frequency response. The Commission has extended the time frame for making a draft determination with respect to AEMO's rule change request, R*emoval of disincentives to primary frequency response during normal operation,* until 24 September 2020 to allow for further consideration of the incentive arrangements under the NER for frequency response during normal operation. The

Commission considers that further refinements to the NER in relation to valuation and remuneration of frequency response should be considered through the assessment of AEMO's second rule change request.

1.2 Background

Frequency performance under normal operating conditions has been deteriorating in recent times, primarily as a result of generators decreasing or removing their responsiveness to minor frequency deviations. Declining frequency performance of the power system contributes to inefficient operation of generators and market outcomes and reduces the resilience of the power system to contingency events.

This degradation of frequency performance was investigated by the Commission through the *Frequency control frameworks review* which concluded in July 2018. The Commission concluded that frequency performance under normal operating conditions had been deteriorating and that changes to the existing frameworks were required to support effective frequency control in the national electricity system. During the *Frequency control frameworks review*, AEMO considered that "time was still available for further investigations to understand [frequency performance] issues" and to address them through the actions included in the AEMC and AEMO *Frequency control work plan.*

The AEMC's final report therefore did not recommend any regulatory change in the immediate term to address the deterioration, but concluded that there is a need to find a more permanent solution to the issue and set out a number of options for further development. However, AEMO's analysis of system behaviour in the 25 August 2018 separation event demonstrated that the reduction in the provision of PFR by the generation fleet has increased the chance of under-frequency load shedding and over-frequency generation shedding following non-credible contingency events.

The following sections provide an overview of the recent degradation of frequency performance in the NEM and an introduction to the key concepts relating to frequency control and primary frequency response.

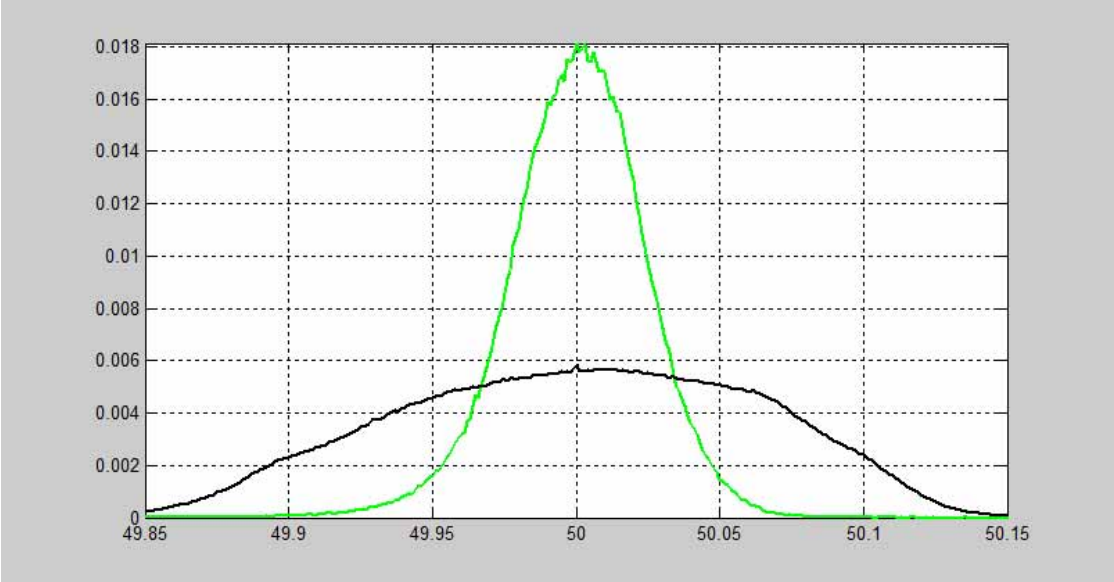
1.2.1 Recent degradation of frequency performance in the NEM

As noted above, frequency performance in the NEM has been declining over the past few years. This degradation of frequency performance has been observed in a widening of the distribution of frequency during normal operation, an increased incidence of oscillations in the power system frequency, and a decrease in the resilience of the power system to non-credible contingency events.[3]

Figure 1.1 shows that the frequency distributions for the mainland and Tasmania are increasingly further away from 50 Hz than has historically been the case.

3 AEMO, Mandatory primary frequency response - Electricity rule change proposal, 16 August 2019, p.17-18.

Figure 1.1: Frequency distribution within the normal frequency operating band in the NEM 2005 snapshot v. 2018 snapshot



Source: AEMO, *Removal of disincentives to the provision of primary frequency response during normal operating conditions — Electricity rule change proposal*, 1 July 2019, p.14.
Note: X-axis: Frequency (Hz)
Note: Green line shows 2005 data, black line shows 2018 data.

AEMO has also reported an increased incidence of exceedance events, where the power system frequency falls outside the normal operating frequency band (NOFB). Many of these excursions have occurred under normal operating conditions in the absence of a contingency event.

There are risks and costs associated with the power system operating more often at frequencies at the edges of the NOFB. Some of the consequences of deteriorating frequency performance include:

- increased wear and tear on plant due to excessive movement caused by frequency deviations
- reduction in the efficiency of generators due to changes in output as result of deteriorating frequency regulation and governor response
- reduction in system security for contingencies that result in significant changes in transfer across inter-connectors
- potential need for additional contingency FCAS to maintain the same level of system security given increased variability of system frequency
- increase in regulating FCAS costs
- possibility of further withdrawal of PFR due to the added burden on existing PFR.

AEMO also highlights that high variability in system frequency makes it more difficult for the Frequency Operating Standard to be met. In addition, it impedes AEMO's ability to model and predict power system behaviour. This, in turn, reduces AEMO's ability to consistently maintain the system in a secure operating state, such that it will recover following a credible contingency event or a protected event.

1.2.2 Frequency control and primary frequency response

The provision of primary frequency response (PFR) has many benefits for frequency control, both during normal system operation and following contingency events. Increasing the provision of PFR across the NEM could materially improve frequency control and reduce reliance on load shedding to preserve the power system during large frequency disturbances.

BOX 1: WHAT IS PRIMARY FREQUENCY RESPONSE?

Primary frequency response (PFR) provides the initial response to frequency disturbances caused by power supply-demand imbalances. It reacts automatically and almost instantaneously to locally measured changes in system frequency outside predetermined set points. PFR involves an automatic change in active power generated (or consumed) by a generator (or load) in response to a change in system frequency measured locally at a plant level.

In order to provide PFR, a generator must operate its plant in a 'frequency response mode' which is defined in chapter 10 of the Rules as: "the mode of operation of a generating unit which allows automatic changes to the generated power when the frequency of the power system changes."

As noted by AEMO in its *Mandatory primary frequency response* rule change request, the key attributes of PFR are that it is:

- **Locally responding** — responds to locally measured frequency and, hence, is not subject to centralised control, communications delays and time synchronisation issues.
- **Fast acting** — provides an immediate action to respond to frequency deviations.
- **Automatic** — responds automatically to adjust generation output to arrest and stabilise frequency, typically in proportion to measured frequency deviation outside predetermined set points.

PFR is a distinctly different service from secondary frequency response. PFR provides fast control action that responds rapidly to contain frequency deviations, while secondary frequency response is a slower control action that acts to relieve PFR providers and to help rebalance energy supply and demand until generation dispatch can be adjusted.

Historically in the NEM, only synchronous generating systems have provided PFR. However, asynchronous generators such as wind, batteries and solar PV, can also provide PFR. As these technologies form an increasingly large proportion of the supply mix, it is important that any

PFR arrangements consider the capabilities and performance of these newer technologies adequately.

PFR can be provided by:

- the variation of generator output by 'governor systems' that regulate the output of generating units
- the variation of active power supplied to or consumed from the power system by inverter based generation and loads.

Under current arrangements, PFR is provided by fast and slow contingency FCAS services that operate outside the normal operating frequency band (NOFB). The NOFB is defined in the frequency operating standard as 49.85 Hz — 50.15 Hz.[4] PFR may also be voluntarily provided by generator governor response and active power control within the NOFB. Providers of PFR within the NOFB are not directly paid for being frequency responsive. However, they are likely to receive a reduced share of the costs of regulation FCAS through AEMO's causer pays procedure.[5]

PFR is required for effective frequency control, in coordination with inertia and secondary frequency control services, for both normal power system operation and following contingency events.[6]

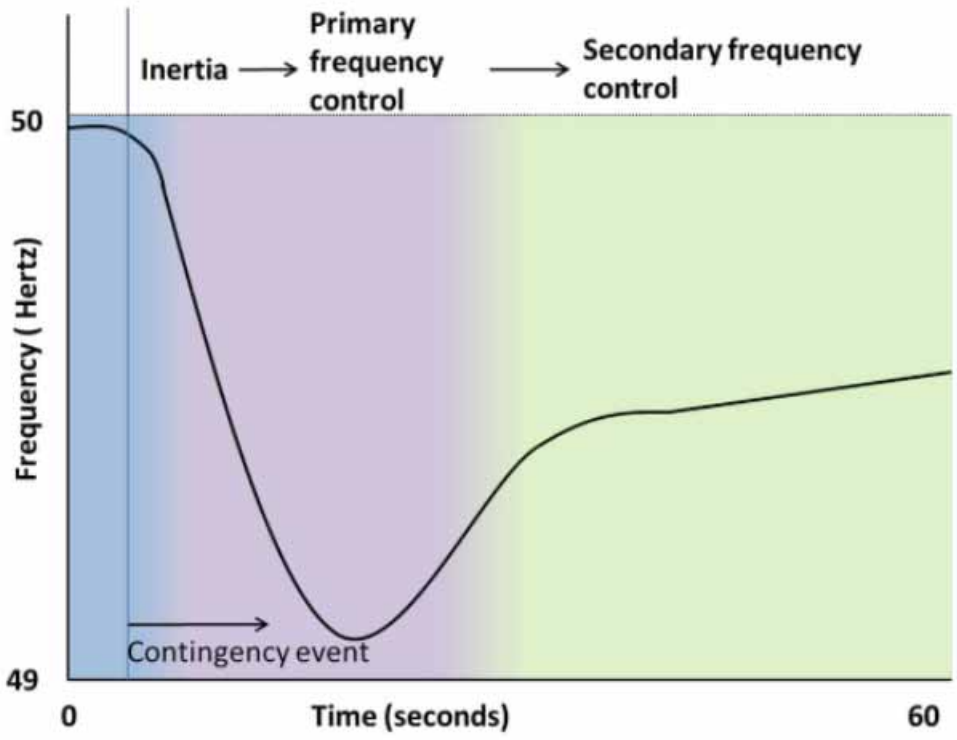
Figure 1.2 below demonstrates how PFR interacts with inertia and secondary frequency control services following a contingency event.

4 AEMC Reliability Panel, Frequency operating standard, 14 November 2017.

5 AEMO's causer pays procedure is the mechanism by which regulation services costs are allocated to Market Generators and Loads on the basis of their contribution factors calculated over a period of a month. These factors reflect the degree to which the generators actual output or, in the case of a scheduled load, their actual demand, differ from the targets assigned by the NEM dispatch engine (NEMDE).

6 Following a sudden change in the balance between generation and load in the power system, the initial rate of change of system frequency following a contingency event is determined by the system inertia. PFR, including that provided by fast and slow FCAS or voluntary response, acts to arrest the change in frequency. The amount of PFR determines the lowest point the frequency reaches, called the 'nadir'. As the PFR is typically proportional to the frequency deviation it is not able to fully restore the frequency to the pre-contingency state. Instead, this is achieved through the provision of secondary frequency response services. Secondary frequency response is provided by delayed and regulating FCAS and responds slower following a contingency event. It takes over from PFR in order to let responsive generating plant return to their normal set-points (and thus be ready for further PFR as required). PFR is essential in arresting frequency deviations and providing time for secondary services to react and restore the power system following a frequency disturbance.

Figure 1.2: Interaction between inertia, and primary and secondary frequency control



Source: AEMC

Overview of AEMO's tools for managing frequency

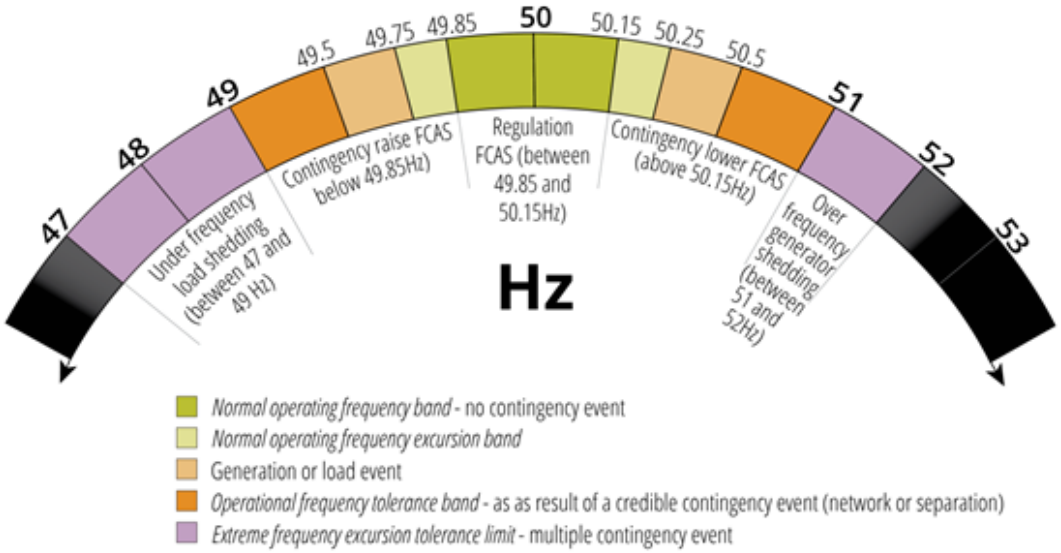
AEMO is responsible under the NER for maintaining power system security. One aspect of this is that AEMO must use its reasonable endeavours to control power system frequency.[7] AEMO controls frequency during normal operation and manages the impact of contingency events through a coordinated use of the following six mechanisms:

- generator technical performance standards (GTPS),
- regulation frequency control ancillary services (FCAS) markets
- contingency frequency control ancillary services (FCAS) markets,
- emergency frequency control schemes (EFCS),
- the protected event framework,
- the reclassification of contingency events.

7 Clause 4.4.1(a) of the NER.

Together, these tools provide AEMO a breadth of methods to address contingency events that may occur in the NEM. The range of tools and the associated frequency bands for which they apply in the mainland NEM are shown below in Figure 1.3.

Figure 1.3: Frequency control tools and active frequency bands



Source: AEMC

1.3 Recent developments on primary frequency response

The AEMC's *Frequency control frameworks review* final report, published on 26 July 2018, identified that one of the main drivers of the recent degradation of frequency performance is generators decreasing or removing the responsiveness of their plant to frequency deviations to avoid actual and perceived disincentives associated with operating their plant in a frequency responsive mode.[8] This has occurred as a result of generators:

- widening their governor deadband such that they are less responsive to frequency changes
- upgrading older mechanical governors to digital control systems, which enable a generator to counteract its mechanical governor response and easily change the frequency response mode of the generator
- where it is more difficult or costly to change their governor settings and uneconomic to upgrade to digital systems, installing secondary control systems to dampen the primary governor response of their generating units, in favour of maintaining alignment of generator output with dispatch targets.

8 AEMC, 26 July 2018, Frequency control frameworks review — Final report, p.69.

Analysis performed for AEMO by DIGsilent confirmed that the net result of these changes to generator control systems has been a reduction in the level of PFR that contributes to maintaining the power system frequency within the NOFB and following large contingency events.[9]

Currently, the NER does not include a regulatory requirement for generators to provide PFR unless they are enabled to provide contingency FCAS through the ancillary service markets. As such, the only PFR that is provided in the NOFB is done so voluntarily.

The AEMC recognises that as some generators reduce or remove their responsiveness to frequency deviations, those that remain experience a greater impact on plant operation, including associated wear and tear costs. This, in turn, strengthens the incentives for generators to further reduce their provision of PFR, continuing the decline in frequency control in the NEM.

The AEMC's Frequency control frameworks review, which concluded in July 2018, provided an important foundation for understanding and assessing the issues. The Commission concluded that frequency performance under normal operating conditions had been deteriorating and that changes to the existing frameworks were required to support effective frequency control in the national electricity system. The final report of the AEMC's *Frequency control frameworks review* highlighted several issues with the existing market and regulatory arrangements for frequency control, and included a collaborative work plan that set out a series of actions that would be progressed by the AEMC, AEMO and the AER to address issues related to frequency control in the NEM over the short, medium and long term.

During the AEMC *Frequency control frameworks review*, AEMO considered that "time was still available for further investigations to understand [frequency performance] issues" and to address them through the actions included in the AEMC and AEMO *Frequency control work plan*. The AEMC's final report therefore did not recommend any regulatory change in the immediate term to address the deterioration, but concluded that there is a need to find a more permanent solution to the issue and set out a number of options for further development. However, the power system incident that occurred on 25 August 2018 led to AEMO confirming an urgent need for regulatory changes to arrest the ongoing decline in the frequency performance in the NEM, in particular the resilience of the NEM to similar major disturbances.[10]

AEMO's operating incident report includes eight recommendations, including some intended to improve the resilience of the power system to contingency events in excess of the largest credible contingency event. AEMO's principal recommendation in the final incident report is the implementation of interim actions, through rule changes as required, to deliver sufficient primary frequency control in the NEM. This recommendation is consistent with the actions set out in the frequency control work plan published as part of the final report for the AEMC's *Frequency control frameworks review* in July 2018.

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

10 AEMO, Mandatory primary frequency response - Electricity rule change proposal, 16 August 2019, p.9.

1.4 Rationale for the rule change requests

AEMO therefore considers frequency response following non-credible contingency events to be a critical issue and so submitted the rule change request, which is the subject of this draft determination.[11]

As set out in its rule change request, AEMO considers that the current tools for managing frequency following contingency events are not sufficient and that there is an immediate need for additional volume of PFR in the NEM to increase the resilience of the power system.[12]

AEMO's rule change requests are related to this work plan. AEMO considers that the decline in frequency performance has reached a point where there is now an immediate need for additional frequency response to restore effective frequency control in the NEM to maintain the safety and security of the power system.

AEMO requested that the AEMC progress its rule change request, *Mandatory primary frequency response*, in the shortest reasonable time frame, balancing the requirement for appropriate consultation with the potential consequences of the ongoing lack of effective frequency control in normal operating conditions. AEMO recognises that its proposed rule for the mandatory provision of primary frequency response is a significant change to the regulatory framework for the NEM, but at the same time the power system assumptions on which the frequency control frameworks were designed have changed and such a significant change in approach is now urgently required.[13]

AEMO set out in its rule change request the following reasons why it considers a regulatory change to provide for effective frequency control in the NEM is required without delay:[14]

- Power system frequency performance during normal operation continues to decline and the events of 25 August 2018 demonstrate the system is now less resilient to contingency events slightly larger than the largest credible contingency event.
- Previously held assumptions of power system behaviour following contingency events are no longer valid, this increases the risk of unexpected outcomes and decreases AEMO's ability to prevent load or generation shedding, and even cascading failure.
- There is now an increased probability of load or generation shedding events. AEMO also note that the rapid and ongoing increase in distributed rooftop PV generation undermines the effectiveness and predictability of UFLS in some regions of the NEM. AEMO believes that UFLS and OFGS should be reserved for managing only the most extreme events where no other options are available. AEMO does not believe it is appropriate that these schemes should be used where there is response capability available from existing generation that would minimise or prevent the use of these emergency, last resort options.

11 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, p.41.
12 Ibid, pp.26-28.
13 Ibid, pp.41.
14 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, p.43.

- The NEM is currently experiencing a rapid rate of connection of new generation, with 7GW of committed projects and 53 GW of proposed projects.[15] AEMO is concerned that delaying the implementation of a new rule requiring PFR will result in a significant volume of new generation being connected without any requirement to operate infrequency response mode except when it is dispatched to provide a market ancillary service.[16]
- AEMO expects that the commencement of the Five-Minute Settlement Rule on 1 July 2021 will increase the challenge of controlling frequency in the NEM. This is based on the expectation that generators will respond to the incentives presented by the shorter settlement time frame by more rapidly increasing or decreasing their output. As a result if broad-based PFR is not available by that date, AEMO expects it will be significantly more difficult to maintain power system frequency to meet the requirements of the FOS both under normal operating conditions and following contingency events.[17]
- AEMO maintains that the physical needs of the power system, in relation to secure operation, are paramount to economic considerations.[18] AEMO considers that it would not be prudent to assume that any mechanism that continues or builds upon the design assumptions of the current FCAS arrangements will ultimately be successful. In contrast, the approach proposed in this rule change is entirely consistent with long standing and demonstrably effective industry practice.[19]

1.5 Solutions proposed in the rule change requests

The following sections provide a summary of AEMO and Dr Sokolowski's proposed rules, including:

- proposals for a mandatory PFR requirement
- other proposed changes to the NER.

1.5.1 Proposals for mandatory PFR proposal

AEMO's proposed mandatory PFR requirement

AEMO's proposed rule includes changes to clause 4.4.2 of the NER to require all scheduled and semi-scheduled generating units and generating systems to be responsive to frequency outside of a defined frequency deadband. Under AEMO's proposed rule, the maximum allowable frequency response deadband, along with other technical characteristics would be determined by AEMO and specified in a new document, the *Primary frequency response requirements* (PFRR) which it would prepare in accordance with the Rules consultation procedures.[20]

AEMO's proposed rule seeks to require all capable scheduled and semi-scheduled generating units to provide PFR once frequency moves outside a defined frequency band. AEMO

15 AEMO, Generation Information, 8 August 2019
16 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, pp.42-43.
17 Ibid, p.43.
18 AEMO, Submission to the Frequency control frameworks review — Draft Report, 26 April 2018, p.8.
19 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, pp.42-43
20 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, pp. 44-45.

suggests that effective control and resilience of the power system would be achieved with a narrow response deadband. AEMO suggests that the allowable deadband be set at ±0.015Hz, which would align power system outcomes in the NEM with standard international practice and provide a stable basis for the ongoing transformation of the generation mix in the NEM.

AEMO's considers that a mandatory requirement for generators to provide PFR is needed for the following reasons.

- **Caters to a more complex and less predictable power system** — Power system disturbances are becoming more complex and less predictable. This can be attributed to physical changes in the power system such as reduced levels of system strength which can increase risks of unexpected control behaviours from inverter connected generation. Greater power system resilience through the broad-based provision of PFR is required to manage these more complex disturbances.[21]
- **Allows for improved power system planning** — A broad-based provision of PFR provides more predictable and consistent generator behaviour supports affective and accurate power system modelling and facilitates good planning and design of emergency frequency control schemes, such as UFLS and OFGS.[22]
- **Increases power system resilience** — The consequences of a disturbance to the power system are minimised if any provider of PFR does not respond as expected, or is unable to respond due to a network separation.[23]
- **Minimises individual generator responses** — The duty on any individual generating unit is minimised because all generators respond together in proportion to their size, both under normal conditions and following disturbances.[24]
- **Minimises the size of power flow changes** — The potential size of power flow changes on the network are reduced in response to an event, which minimises the consequential impacts of disturbances.[25]

AEMO's rule change proposal is supported by advice provided by international power system expert, Dr. John Undrill, that an obligation to provide PFR should apply to all generating systems, to the extent that it is practical to do so.[26] This is intended to be a conservative and prudent approach to maintaining system security and resilience within a power system that is undergoing rapid technological transformation.

Dr Sokolowski's proposed mandatory PFR requirement

Dr. Peter Sokolowski's rule change request also proposes a mandatory obligation that would be implemented through the generator performance standards in S5.2.5.11 of the NER and be intended to apply to all registered generation in the NEM.

---

21 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, p.24.
22 Ibid, p.26.
23 Ibid, p.20.
24 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, p.20.
25 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, p.37.
26 Dr. John Undrill, *Notes on frequency control for the Australian Energy Market Operator*, 5 August 2019, p.3.

1.5.2 Other proposed changes to the NER

Other proposed changes in AEMO's rule change request

AEMO's proposed rule includes changes to cl 4.9.4 and cl 4.9.8 to clearly acknowledge that it is expected and acceptable for generation output to vary from dispatch targets when providing PFR. The proposed changes are summarised below:

- Under cl 4.9.4(a), sub-clause 4(ii) is deleted and a new sub-clause 3A is included to confirm that a scheduled or semi-scheduled generator may send out energy from a generating unit as a consequence of operating in a frequency response mode to help control system frequency.
- Under cl 4.9.8, a new sub-clause is added to confirm that a scheduled or semi-scheduled generator is not taken to have failed to comply with a dispatch instruction as a consequence of the operation of a generating unit in frequency response mode to help control system frequency.

AEMO's intent is that these proposed changes will remove stakeholder concerns around the provision of PFR resulting in non-compliance with dispatch targets.[27]

AEMO's rule change request also identifies that a recent change to the NER made as part of the Generator technical performance standards rule 2018, may be compounding the perception by some generators that the NER be interpreted as suggesting that a generator need not operate in a frequency response mode unless it is enabled to provide FCAS through the markets for ancillary services.[28]

Operating in a frequency responsive mode once connected is at a generator's discretion, except when a generator elects to participate in a contingency frequency control ancillary service (FCAS) market. Clause S5.2.5.11(i)(4) in the NER sets out that a generating system is required to operate in frequency response mode only when it is enabled for the provision of a relevant market ancillary service.

AEMO's rule change request identifies that some generators interpret clause S5.2.5.11(i)(4)of the NER as supporting them to turn off or counteract their plants responsiveness to frequency unless they are enabled for the provision of FCAS.

Other proposed changes in Dr. Sokolowski's rule change request

Dr. Peter Sokolowski's rule change request also proposes a number of other changes to the NER that are intended to improve frequency control and system security in the NEM. The proposed rule revises:[29]

- clause 3.15.6A(5) to clarify that, for the purposes of determining a contribution factor for the allocation of regulation FCAS costs, a market participant is expected to achieve its dispatch targets at uniform rates subject to the provision of PFR.

27 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, p.45.
28 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, p.13.
29 Dr Sokolowski, Primary frequency response requirement — Electricity rule change proposal, 30 May 2019, p. 7.

- clause 4.9.4(a)(4) to clarify that both a scheduled and a semi-scheduled generating unit may send out energy as a consequence of operating in a frequency response mode subject to local power system conditions.
- clause S5.2.5.14 clarify that a scheduled generating unit or a scheduled generating system should be capable of controlling its active power output "subject to local frequency".
- clause 4.3.1 of the NER to align with S49(1)(e) of the NEL and clarify that AEMO is responsible not only to maintain power system security but also to improve it.[30]
- clause 5.20B.5(g) to explicitly refer to fast frequency response as being a potential source of inertia support activities, and revise the Chapter 10 definition of inertia.

1.6 The rule making process

On 19 September 2019, the Commission published a notice advising of its commencement of the rule making process and consultation in respect of the rule change requests.[31] A consultation paper identifying specific issues for consultation was also published. Submissions closed on 31 October 2019.

The Commission received 31 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. Issues that are not addressed in the body of this document are set out and addressed in appendix f.

The Commission also formed a technical working group of experts from industry, and consumer groups and convened a technical working group meeting on 18 November 2019.

On 19 December 2019, the Commission published a notice to consolidate its assessment of the two rule change requests — ERC0274 Mandatory primary frequency response and ERC0277 Primary frequency response requirement. These are the subject of this rule change request.

Consistent with the request from AEMO, the AEMC has considered these rule changes as a priority, with the draft determination published earlier than the AEMC is required to do under the statutory time frames.

1.7 Consultation on draft rule determination

The Commission invites submissions on this draft rule determination, including the more preferable draft rule, by 13 February 2020.

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 9 January 2020.

30 Dr. Peter Sokolowski, Primary frequency response requirement - Electricity rule change proposal, 30 May 2019, p.12.

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

Submissions and requests for a hearing should quote project number ERC0274 and may be lodged online at www.aemc.gov.au.

2 DRAFT RULE DETERMINATION

2.1 The Commission's draft rule determination

The Commission's draft rule determination is to make a more preferable draft rule (hereafter called "draft rule").

The draft rule is attached to and published with this draft rule determination. The more preferable draft rule:

- creates an obligation on each scheduled generator and semi-scheduled generator that has received a dispatch instruction to generate at a volume greater than 0 MW to operate its generating system in accordance with the PFRR as applicable to that generating system
- clarifies that compliance with the above obligation does not require a scheduled generator or semi-scheduled generator to maintain additional stored energy for the purposes providing frequency response in accordance with the requirements of the PFRR
- creates an obligation on AEMO to develop, publish on its website and maintain the PFRR in accordance with the Rules consultation procedures[32]
- sets out that the PFRR must include:
    - a requirement that Scheduled Generators and Semi-Scheduled Generators set their generating systems to operate in frequency response mode within one or more performance parameters (which may be specific to different types of plant) including: maximum allowable deadbands (which must not be narrower than the primary frequency control band — the range of 49.985 Hz to 50.015 Hz or such other range as specified by the Reliability Panel in the FOS) outside of which Scheduled Generators and Semi-Scheduled Generators must provide primary frequency response; droop; and response time;
    - the conditions or criteria on which a Scheduled Generator or Semi-Scheduled Generator may request, and AEMO may approve, a variation to, or exemption from, any performance parameters applicable to its generating system;
    - the process and timing for an application for a variation or exemption, and the process for approval by AEMO;
    - details of the information to be provided by Scheduled Generators and Semi-Scheduled Generators to verify compliance with the PFRR and any compliance audits or tests to be conducted;
- creates an obligation on AEMO to publish on its website and maintain a register of Generators who have been granted an exemption or variation from the PFRR
- sets out the matters and principles that AEMO must have regard to when approving a variation or exemption including:
    - the capability of the generating system to operate in frequency response mode;

32 The PFRR will need to be revised from the current draft version to reflect this draft rule.

  - the costs that are likely to be incurred in augmenting the generating system to be able to operate in frequency response mode relative to the turnover derived from the expected operating hours of the generating system in relation to its operation in the national electricity market;
  - the stability of the generating system when operating in frequency response mode, and the potential impact this may have on power system security;
  - the ongoing costs of operating the generating system in frequency response mode; and
  - any other physical characteristics which may affect the ability of the generating system to operate in frequency response mode, including but not limited to dispatch inflexibilities, operating requirements, or energy constraints.
- clarifies that a Registered Participant which has classified a scheduled generating unit, scheduled load, ancillary services generating unit or ancillary service load will not be assessed as contributing to the deviation in the frequency of the power system if within a dispatch interval it achieves its dispatch target at a uniform rate subject to the provision of PFR by that Participant in accordance with the PFRR. This removes a potential disincentive for voluntary provision of PFR by a Registered Participant with scheduled or ancillary service load.
- clarifies that a Scheduled Generator or Semi-Scheduled Generator is not taken to have failed to comply with a dispatch instruction as a consequence of it operating its generating unit in frequency response mode to adjust power system frequency in response to power system conditions
- Introduces transitional arrangements that require AEMO to:
  - make and publish on its website interim Primary Frequency Response Requirements by 4 June 2020 to apply until the first Primary Frequency Response Requirements are made.
  - publish a draft of the interim Primary Frequency Response Requirements on its website by 9 April 2020 and provide at least 20 business days for written submissions on this draft.
  - develop and publish the first Primary Frequency Response Requirements under the new rules by 6 December 2021.

The more preferable draft rule also includes Schedule 2 which removes the mandatory primary frequency response framework from the rules as at 4 June 2023. This allows for an incentive based arrangement to be developed. The relevant rules will then revert to the version of those rules in existence at the time this rule is made.

An overview of the more preferable draft rule can be found in chapter 4 with more detailed discussion of the various elements found in the accompanying appendices.

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

This chapter outlines:

- the rule making test for changes to the NER

- the more preferable rule test
- the assessment framework for considering the rule change request
- the Commission's consideration of the more preferable draft rule against the national electricity objective

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

2.2 Rule making test

2.2.1 Achieving the NEO

Under the NEL 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).[33] This is the decision making framework that the Commission must apply.

The NEO is:[34]

> 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.

2.2.2 Making a more preferable rule

Under s.91A of the NEL, the Commission may make a rule that is different (including materially different) to a proposed rule (a more preferable rule) if it is satisfied that, having regard to the issue or issues raised in the rule change request, the more preferable rule will or is likely to better contribute to the achievement of the NEO than the proposed rule.

In this instance, the Commission has made a more preferable draft rule. The reasons are summarised below. More detailed reasons for making this more preferable draft rule, including detailed analysis of the issues raised and responses to them, are set out in Appendix A, Appendix B, Appendix C and Appendix D.

2.2.3 Rule making in relation to the Northern Territory

The NER, as amended from time to time, apply in the Northern Territory, subject to derogations set out in regulations made under the Northern Territory legislation adopting the NEL.[35] Under those regulations, only certain parts of the NER have been adopted in the Northern Territory.[36]

---

33 Section 88 of the NEL.

34 Section 7 of thence.

35 The regulations under the NT Act are the National Electricity (Northern Territory) (National Uniform Legislation) (Modifications) Regulations.

36 The version of the NER that applies in the Northern Territory is available on the AEMC website.

As the draft rule either relates to parts of the NER that currently do not apply in the Northern Territory or have no practical application in the Northern Territory, the Commission has not assessed the rule against the additional elements required by the Northern Territory legislation.[37]

2.3 Assessment framework

The Commission has sought to prioritise solutions to the issues raised in the rule change requests from AEMO and Dr. Sokolowski in accordance with the following hierarchy of priorities:

1. Addressing risks to power system security associated with the degradation of frequency control in the NEM and the withdrawal of PFR from market participants not enabled to provide FCAS
2. Alleviating disincentives in the NER to market participants operating their plant in a way that helps correct frequency deviations
3. Improving incentives for market participants to operate their plant in a way that helps correct frequency deviations.

AEMO requested that its rule change request for mandatory primary frequency response be assessed in the shortest reasonable time frame, balancing the requirement for appropriate consultation with the potential consequences of the ongoing lack of effective frequency control during normal operating conditions. In determining the immediate solution, the Commission is seeking to address system security first and foremost. Whilst the Commission acknowledges the need to create incentives for parties to provide primary frequency response, it also considers that developing such arrangements should not come at the expense of a secure and stable power system. The Commission considers that the implementation of a mandatory primary frequency response requirement will meet the immediate fundamental system security needs identified by AEMO in its rule change request. Following this, the Commission will seek to investigate further improvements to the frequency control arrangements that would incentivise and reward participants for providing primary frequency response.

This approach is consistent with the frequency control work plan that was agreed as part of the *Frequency control frameworks review* in which the Commission recommended the development of a mechanism to incentivise the provision of a sufficient quantity of PFR over the long term to support good frequency performance during normal operation. The Commission has prepared an update to this work plan in collaboration with AEMO which sets out a pathway to the development of future arrangements to create incentives for the provision of primary frequency response. This work plan is explored further in chapter 3.

37 From 1 July 2016, the NER, as amended from time to time, apply in the NT, subject to derogations set out in regulations made under the NT legislation adopting the NEL. Under those regulations, only certain parts of the NER have been adopted in the NT. (See the AEMC website for the NER that applies in the NT.) National Electricity(Northern Territory) (National Uniform Legislation) Act2015.

In assessing the consolidated rule change request, the Commission has considered whether the proposed rules are likely to support and improve the security of the power system along with their impacts on the effectiveness and efficiency of frequency control frameworks.

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

- **Promoting power system security:** The operational security of the power system relates to the maintenance of the system within pre-defined limits for technical parameters such as voltage and frequency. System security underpins the operation of the energy market and the supply of electricity to consumers. The Commission has had regard to the potential benefits associated with improvements to system security brought about by the proposed rule changes, weighed against the likely costs. In relation to system security, a rule for the provision of PFR is likely to be consistent with the NEO if the operational costs of compliance and service provision are less than the estimated risk based costs of unserved energy associated with generation and load shedding following non-credible contingency events.
- **Appropriate risk allocation:** The allocation of risks and the accountability for investment and operational decisions should rest with those parties best placed to manage them. The arrangements that relate to frequency control should recognise the technical and financial capability of different types of market participants to respond to changes in frequency. Where practical, operational and investment risks should be borne by market participants, such as businesses, who are better able to manage them.
- **Efficient investment in, and operation of, energy resources to promote secure supply:** The market and regulatory arrangements that relate to frequency control should result in efficient investment in, and operation of, energy resources to promote a secure supply of electricity for consumers. The frequency control frameworks should also seek to minimise distortions in order to promote the effective functioning of the market. In the case of the arrangements for frequency control, market participants should be encouraged to invest in and operate plant in a way that supports the control of system frequency.
- **Technology neutral:** Regulatory arrangements should be designed to take into account the full range of potential market and network solutions. They should not be targeted at a particular technology, or be designed with a particular set of technologies in mind. Technologies are changing rapidly, and, to the extent possible, a change in technology should not require a change in regulatory arrangements.
- **Flexibility:** Regulatory arrangements must be flexible to changing market and external conditions. They must be able to remain effective in achieving security outcomes over the long-term in a changing market environment. Where practical, regulatory or policy changes should not be implemented to address issues that arise at a specific point in time. Further, NEM-wide solutions should not be put in place to address issues that have arisen in a specific jurisdiction only. Solutions should be flexible enough to accommodate different circumstances in different jurisdictions. They should be effective in facilitating security outcomes where required, while not imposing undue market or compliance costs.

- **Transparent, predictable and simple:** The market and regulatory arrangements for frequency control should promote transparency and be predictable, so that market participants can make informed and efficient investment and operational decisions. Simple frameworks tend to result in more predictable outcomes and are lower cost to implement, administer and participate in.

2.4 Summary of reasons

In assessing whether the proposed rule is likely to meet the NEO, the Commission has balanced the power system needs and related benefits associated with improving system security, resilience and power system frequency control against the cost of delivering those outcomes. The Commission notes that while improved frequency control may provide benefits to consumers by delivering enhanced power system security and resilience, such improvements may also incur additional costs which are ultimately likely to be borne by consumers.

The Commission accepts the views expressed by AEMO in its rule change request that a mandatory requirement for primary frequency response applied to a broad cross-section of the generating fleet would mean that costs incurred by each *individual* generator would likely be minimised. If every scheduled and semi- scheduled generator provides primary frequency response then this will minimise the costs for each individual generator, since no one generator will bear the burden of responding — instead, this will be shared across the entire fleet.

Given that the wholesale market is competitive, this means that the generators will all be able to recover their costs through adjusting their energy market offers, and so in turn, wholesale energy market prices. Wholesale electricity prices will reflect the necessary cost of providing primary frequency response in order to manage system security. Obviously, it will be harder for generators with higher costs than the marginal generator, and those that are lower in the merit order to recover their costs through the energy market. However, the Commission considers that this is likely to be manageable.

Having regard to the issues raised in the consolidated rule change request and during consultation, the Commission is satisfied that the more preferable draft rule will, or is likely to, better contribute to the achievement of the NEO than the proposed rule for the following reasons.

- An increase in the provision of primary frequency response from generators will improve the security of the national electricity system for the benefit of consumers and will give AEMO more confidence that it is maintaining the power system in a secure operating state. Any frequency response that is provided addition to the markets for contingency capacity reserves, or FCAS, offset the need for generation and load shedding to rebalance supply and demand following a contingency event that exceeds the largest credible contingency event. Improved frequency control will decrease the risk of generation shedding and decrease the risk of unserved energy associated with load shedding following large contingency events.

- Improvements in the efficiency of wholesale market operation due to AEMO being able to more accurately measure and predict of the system operating state. Improved frequency control during normal operation means that the frequency will be maintained more closely to 50 Hz and therefore the assumptions that relate to system frequency that underpin the operation of the energy market are likely to be more accurate. This may translate into improved accuracy of demand forecasts and improved market dispatch efficiency by AEMO, thereby reducing wholesale energy prices for the benefit of consumers.
- Improved frequency performance, particularly during normal operation translates into a more stable system frequency that is maintained more closely to 50 Hz. This improvement in frequency control may lead to a reduction in operation and maintenance costs for synchronous generating plant. The rotating speed of synchronous plant is directly linked to the power system frequency, which means that any change in system frequency causes a direct change in the rotating speed of the generator and turbine. The ongoing instability of power system frequency can therefore translate into stress on the components of the generation plant, which over time may lead to an increased need for plant maintenance. The costs of plant maintenance include the direct costs of replacement parts and labour along with the lost revenue associated with plant shut-downs to undertake the maintenance. Smoother operation of synchronous generating plant and a reduction in maintenance and shut-down costs will improve reliability outcomes and lower wholesale energy prices in the interests of consumers.

The Commission considers that the draft rule is more preferable than the proposed rule for the following reasons.

- The draft rule introduces a new *primary frequency control band* of 49.985 Hz to 50.015 Hz, which sets a lower bound on the deadband to which individual generators must comply under the conditions of the PFRR. The Commission considers that the *primary frequency control band* is a key variable associated with the draft rule, which has implications for both system operation and the operation of the markets for electricity and ancillary services in the NEM. In the absence of a clearly defined frequency performance standard in the frequency operating standards, the Commission has determined that the lower bound for the *primary frequency control band* be specified in the NER, and not subject to full discretion by AEMO in the PFRR. This will provide for a comprehensive assessment of any potential changes to the *primary frequency control band*, as it applies to generators, relative to the potential benefits that it provides to the security of the power system.

- The Commission has specified in the draft rule that the PFRR cannot require generators to maintain additional headroom or stored energy for the purpose of providing primary frequency response.[38] The Commission acknowledges that AEMO does not propose to include a requirement in the PFRR that generators maintain headroom as part of its proposed rule. However, the PFRR is subject to change, and any future obligation which results in a large cross-section of the generating fleet maintaining headroom would likely impose substantial costs on generators that outweigh the additional benefits this might provide to the security of the power system. This aspect of the draft rule will provide greater clarity and certainty to generators and will limit the likelihood of substantial unwarranted costs being incurred by generators in the future, thereby limiting impacts on wholesale prices for the benefit of consumers.
- The draft rule requires that the PFRR includes provision for generators to request, and AEMO approve, an exemption or variation from the requirements specified by AEMO in the PFRR applicable to their generating system. The draft rule sets out a series of principles to guide AEMO in considering any such requests. The Commission expects that the costs for each generator to meet the performance parameters for PFR will vary, with some plant requiring significant plant upgrades and control system tuning in order to provide PFR in accordance with the performance parameters. The exemption framework introduces a degree of flexibility that avoids excessive compliance costs for eligible generation plant while still delivering on AEMO's system security and frequency control objectives.
- While a mandatory approach may be necessary in the interim in order to meet immediate system security needs, it would be preferable for this approach to be complemented in the longer-term by incentives and rewards for providing frequency response. Given the time associated with developing such arrangements it is not possible to do this in time to address the immediate system security needs. Therefore, the draft rule includes provision for a sunset after a period of three years. This creates a clear signal that the Commission is committed to the development of an arrangement that appropriately incentivises primary frequency response provision to be put in place prior to the sunset.

While the benefits associated with the provision of narrow band PFR are difficult to quantify, there is likely to be a minimum set of technical requirements and a corresponding proportion of responsive generation where the operational needs of the power system are met. Beyond this point the incremental benefits of more stringent technical requirements or a larger proportion of the fleet being responsive are likely to diminish. At the same time, the incremental upfront costs of implementing a new mechanism for the provision of PFR are likely to increase as the technical requirements are strengthened or the proportion of the fleet that is responsive is increased.

38 Available headroom for frequency response refers to the capacity for a generator to raise its generation output in response to a drop in system frequency. It is dependent on the generating level of the plant based on market dispatch along with energy source availability and plant operating limits. Unless curtailed due to system constraints, semi-scheduled generators such as solar and wind power stations typically do not maintain stored energy or headroom, as their generation output is limited by the energy availability of the wind or sun. On the other hand, scheduled generators including thermal, hydro and batteries typically operate with some level of stored energy availability which varies by plant type. Scheduled generators maintain stored energy for a range of reasons, including maintaining a minimum ramp rate capability and in accordance with being enabled in the market for provision of frequency control ancillary services.

While this cost benefit trade-off could be made dynamically through a more sophisticated policy mechanism, such as a new market or incentive-based arrangement, the Commission recognises that there is an immediate need for improved frequency control in the NEM. The Commission considers that it is not appropriate to continue to operate the NEM without effective frequency control during normal operation, and that a regulatory change is needed now in order to restore effective frequency control and resolve immediate system security concerns. The Commission is satisfied that the draft rule to mandate the provision of PFR, together with the proposed exemption framework will meet the immediate need for effective frequency control while limiting the costs associated with the implementation of such an approach to those costs that are necessary to meet the immediate system security need.

The Commission considers that the economic optimisation of the provision of PFR is an important consideration in minimising the long-term costs to consumers. A performance-based pricing approach, as recommended in the *Frequency control frameworks review*, will require a longer time period for design and implementation. Furthermore, the necessary testing and trialling of such a mechanism would not likely be appropriate in the current power system, where a deficiency in good frequency performance has been identified. The development and implementation of a framework to more effectively optimise the economic provision of frequency control will be undertaken when the immediate system needs are satisfied. The inclusion of a sunset arrangement for the mandatory primary frequency response requirement means that this will need to be implemented prior to June 2023. Chapter 3 sets out further detail on the Commission's long-term reform pathway.

ONGOING FREQUENCY CONTROL WORK PLAN

The key deliverable arising from the AEMC's *Frequency control frameworks review* in July 2018 was a work plan developed collaboratively by the AEMC, AEMO and the AER, in consultation with stakeholders, which set out a series of actions to address a range of frequency control issues over the next few years.

A key action in the *Frequency control work plan* itself was the development of a longer-term mechanism for the procurement of a primary regulating response and other frequency services as the needs of the power system evolve. The work plan also set out a range of short-term actions for AEMO to undertake in an attempt to better understand the drivers of the deterioration, and to appropriately address it. At the time, AEMO advised that there was no immediate need to implement regulatory change to address the deterioration in frequency performance before the results of its short-term actions to understand the issue are known, and that current regulatory tools were expected to be adequate to manage frequency performance in a manner consistent with the requirements of the frequency operating standard within this time frame.

However, based on the power system events on 25 August 2018, AEMO now considers that there is an urgent need to improve the control of power system frequency in the NEM.

This draft rule has been made in response to AEMO's rule change request, *Mandatory primary frequency response,* and Dr. Peter Sokolowski's rule change request, *Primary Frequency Response Requirements*. The AEMC has made the draft rule to address the immediate need, as identified by AEMO, to reinstate narrow band frequency response from the generation fleet to improve the resilience of the power system.

The AEMC remains committed to the implementation of further reforms to appropriately value and reward the provision of frequency control services and, in collaboration with AEMO, has revised the *Frequency control work plan*.

This chapter outlines:

- The AEMC's considerations for progressing a reform pathway for frequency control and the development of incentive-based arrangements for PFR
- Stakeholders' views on the development of frequency control mechanisms
- The draft revised *Frequency control work plan*

3.1 The draft rule is part of the frequency control work plan

The draft rule is part of the *Frequency control work plan* that was initiated through the *Frequency control frameworks review*. The work plan included an action that AEMO:[39]

> communicates whether there is a need to implement interim measures before a longer-term mechanism for primary frequency control within the normal operating frequency band comes into effect.

39 AEMC, 26 July 2018, Frequency control frameworks review — Final report, p.62.

As set out in the consultation paper, the Commission intends to continue to progress its frequency control reform agenda as outlined in the *Frequency control work plan*. In particular, when the fundamental and immediate system security needs are met, the Commission will seek to investigate, and consult on, further improvements to the frequency control arrangements to increase the overall economic efficiency of frequency control in the NEM.

To reflect the commitment to the ongoing reform of the frequency control frameworks, the AEMC, in collaboration with AEMO, have developed a draft revised *Frequency control work plan.* The revised work plan is based on the plan published at the end of the *Frequency control frameworks review* and provides an update on progress to date on key actions along with an indication of the next steps in the reform pathway for frequency control frameworks in the NEM.

The following sections set out:

- how the immediate system security need will be addressed in the short-term and the inclusion of a three-year sunset in the draft rule.
- the Commission's next steps for the development of a mechanism to provide a payment to providers of PFR during normal operating conditions.

3.1.1 Addressing the short-term system security need and the inclusion of a sunset period

The Commission acknowledges that a rule that introduces a mandatory requirement for generators to activate an existing capability to provide PFR is likely to address the immediate need for improved frequency control in the NEM. However, the Commission recognises that a mandatory requirement for PFR is not a complete solution and it would be preferable to introduce arrangements that incentivise and reward the provision of frequency control in the NEM. In developing such an arrangement, the Commission recognises the need to properly consider other alternative and complementary measures, including the potential for new market and incentive-based mechanisms for frequency control. Further works also need to be done to understand the power system requirements for maintaining good frequency control. Many stakeholders share this perspective, as discussed in section 3.3.

In the context of the full range of solutions identified through the *Frequency control frameworks review* to improve frequency control during normal operation, the Commission considers that the mandatory PFR requirement is only acceptable in isolation for an interim period. The Commission is mindful of the costs that such a mechanism, on its own would impose on generators. While these may be necessary in the interim in order to meet immediate system security needs, it would be preferable for these to be complemented by incentives and rewards for providing frequency response. Given the time associated with developing such arrangements it is not possible to do this in time to address the immediate system security needs.

Therefore, the draft rule includes provision for a sunset after a period of three years. This creates a clear signal that the Commission is committed to the development of an arrangement that appropriately incentivises primary frequency response provision to be put in place prior to the sunset.

This was supported by a number of stakeholders in response to the consultation paper. These stakeholders suggested that if the Commission were to introduce a mandatory PFR requirement in the NER, it should be time limited or include a sunset clause as an assurance that it would be a temporary arrangement, and that there would be consideration of arrangements to incentivise parties in the longer-term.[40] Namely:

- The AEC recommended a three-year sunset period
- Alinta and Energy Australia recommended a two-year sunset period
- Enel X considers any interim solution for PFR be time-limited but does not specify a time period

Once the immediate system security concerns are addressed, the ESB, AEMO, the AER and the AEMC will be better placed, in terms of time frames and flexibility, to further develop new approaches to frequency control and PFR. The Commission considers that three years would afford all market bodies adequate time to work collaboratively in determining the most efficient long-term mechanism for procuring PFR in the NEM.

3.1.2 Next steps for the development of appropriate incentive arrangement for PFR

The next steps for progressing the *Frequency control work plan* include:

- The making of a rule which implements a mandatory PFR requirement to address the immediate need for effective frequency control in the NEM during normal operation and following contingency events.
- The extension of the assessment period for AEMO's other PFR rule change request, *Removal of disincentives to primary frequency response,* which would mean a draft determination will be published in September 2020 to allow time to consider improvements to the incentive arrangements that relate to frequency control during normal operation.

The Commission will use AEMO's second rule change request (*Removal of disincentives to primary frequency response*) to consider and develop appropriate incentive arrangements for providers of primary frequency response.

This rule change request identifies issues in the NER that relate to the existing incentive arrangements for market participants to help to control system frequency during normal operation, including the process for the allocation of costs associated with regulation FCAS. Therefore, the Commission's consideration of an appropriate solution will include refinement of the aspects of the NER that relate to the allocation of costs associated with regulation FCAS through the causer pays procedure. The Commission will consult with stakeholders on the scope and direction for this rule change process in early 2020.

The expected timeline for progression of the *Removal of disincentives to the provision of primary frequency control* rule change request is as follows:

- Scoping process completed in Q2 2020
- Draft determination published in September 2020

40 Submissions to the Consultation paper: AEC, p.3, Alinta, p.2, Energy Australia, p.9, Enel X p.8.

- Final determination published in December 2020
- Ongoing consultation with stakeholders through the continuation of the technical working group throughout the rule change process

The statutory steps for the *Removal of disincentives to the provision of primary frequency control* rule change request are included in the draft updated *Frequency control work plan* in section 3.4.3.

3.2 AEMO's views on long-term reform

As AEMO stated in its submission to the *PFR rule changes* consultation paper, AEMO supports the development of an incentive-based mechanism for PFR over the long-term, provided a mandatory requirement for PFR is implemented first:[41]

> Once the mandatory PFR rule is made and implemented, AEMO would work with the AEMC and industry on options for incentivising a market mechanism for PFR.

While AEMO is committed to investigating different mechanisms for procuring frequency control services through the *Frequency control work plan*, as explicitly stated in AEMO's *Mandatory primary frequency control* rule change request[42], AEMO does not believe an incentive-based mechanism on its own would be sufficient to meet the system security needs of the system. AEMO envisages that any proposed incentive arrangement for PFR would have to exist in parallel with the mandatory PFR requirement:[43]

> AEMO supports the development of new mechanisms to incentivise better performance than what is required by the PFRR only if they operate in parallel to a near-universal PFR obligation. AEMO does not believe an incentive mechanism alone could achieve all objectives of its rule change requests without ensuring a broad level of participation.

AEMO considers that there is little international experience in relying on incentive mechanisms alone for the provision of PFR.[44]

AEMO notes that the existing Contingency and Regulation FCAS markets will continue to provide commercial arrangements for the procurement of frequency control services and AEMO is undertaking work to remove disincentives for generators to offer reserves into these markets. In line with this, AEMO is undertaking a range of actions relevant to the *Frequency control work plan* which will progress work by AEMO and the AEMC towards improved mechanisms for procuring PFR, including:

- work to better understand the frequency control needs of the future power system, such as AEMO's Renewable Integration Study (RIS),[45]

41 AEMO, submission to the *PFR rule changes* consultation paper, 31 October 2019, pg. 1
42 AEMO, *Mandatory primary frequency control* rule change request, August 2019, pp. 7-9
43 ibid., p. 10
44 ibid.
45 See: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Future-Energy-Systems/Renewable-Integration-Study

- review and make improvements to current frequency control mechanisms, including contingency FCAS quantities, AGC systems and an ongoing review of the MASS.

3.3 Stakeholder views

The following sections summarise stakeholder submissions to the consultation paper in relation to the appropriateness of a mandatory PFR requirement and the development of incentive and market-based arrangements to value PFR.

It also includes an overview of some alternative pathways to progress reform of the frequency control frameworks proposed by Delta Electricity and CS Energy in their submissions.

3.3.1 General advocacy for a more efficient mechanism for PFR

In response to the consultation paper, many stakeholders expressed concern that the proposed mandatory PFR requirement is unlikely to be the most efficient option for valuing primary frequency response in the long-term. These stakeholders reasoned that incentive or market-based arrangements to provide PFR would likely be more efficient and effective over the longer term.[46] Stakeholders highlighted a number of key concerns with the existing frameworks which they believe could be efficiently addressed through an incentive-based mechanism for PFR, including:

- PFR should be valued to reflect the costs to generators of providing the service
- Generators should be incentivised to maintain headroom if a PFR mechanism is to be technically effective
- PFR should be procured at economically efficient levels
- Appropriate economic signals should exist for investment and innovation

Many stakeholders have also expressed preference for particular types of incentive mechanisms to be developed.

Proposed voluntary PFR trial

The AEC has proposed an industry lead voluntary provision of narrow band primary frequency response to address the immediate power system need for effective frequency control. The AEC provides the following detail in its submission to the consultation paper:[47]

> The AEC conducted a confidential survey of its members to identify whether plant would now be made available for a re-attempt of a similar trial. These responses have offered over 9,000MW of steam plant which seems more than adequate for the original objective. This would achieve the Undrill report's recommendation that one-third of the connected mainland capacity participate in such a trial.
>
> Thus, AEC members stand ready to assist, under AEMO direction, with voluntary

46 Submissions to the consultation paper: CS Energy, p. 2, Delta Electricity, p. 6, Neoen p. 1, Enel X, p. 8, IES, p.2, Enel Green Power, p. 2, ARENA, p.3.

47 AEC, Submission to the consultation paper, 31 October 2019, p.5.

provision of PFR that would:

- Remove the sense of urgency that exists in processing such significant rule changes; and
- Allow AEMO to determine the key technical and market matters that they identified as lacking at the end of the FCFR.

The AEC urges the AEMC to extend consideration of these rule changes such that the trial and research process that was envisaged by the FCFR final report may be carried out.

AEMO responded to the AEC's proposal in its submission to the consultation paper:[48]

> The voluntary provision of PFR might also be helpful in identifying the actual impact on individual generating units/systems of changes to their control systems, however, volunteered generating plant is likely to experience an increase in the operating impact above what would be expected with broader system-wide PFR provision, due to the greater individual burden placed on the limited, volunteered plant.
>
> AEMO emphasises that a voluntary trial of increased provision of PFR from a limited group of generating systems cannot be a durable substitute for the broad requirement proposed in the rule change requests. Among other reasons, it would be dependent on voluntary participation which, in theory, could be withdrawn at any time. Such an arrangement would only serve as a stop-gap mechanism at best, and would not fully or reliably achieve the objectives of the rule change requests.

The AER also commented on AEC's proposal for a voluntary trial in its submission to the consultation paper, expressing support for its realisation.[49]

> We also note the Australian Energy Council (AEC) has put forward an interim solution for some generators to voluntarily provide PFR for a trial period. This appears to be a practical and pragmatic solution that can be quickly implemented to address the urgency of this issue. This interim solution will allow time for further study of the issue, including how much PFR is required to restore frequency performance to acceptable levels—which is not currently well understood. Such a trial approach was recommended by the AEMC in its 2018 review.

The Commission understands that AEMO are supportive of industry lead efforts to improve system performance and appreciates efforts made by the AEC and its members in trying to bring together sufficient plant to offer a voluntary mainland trial of PFR. However, AEMO does not see the offer for a voluntary trial as a suitable substitute for the immediate implementation of the PFR requirement. AEMO considers that the proposed voluntary scheme would be a departure from the primary objective of the Mandatory PFR rule change proposal to maximise participation from scheduled and semi-scheduled plant to increase the resilience

48 AEMO, Submission to the consultation paper, 31 October 2019, p.9.

49 Submission to the consultation paper, AER, p. 2.

of the power system. This objective is documented in the rule change request and the accompanying advice from Dr. John Undrill, as well as power system operating practice in other international jurisdictions.

The Commission accepts AEMO's advice that there is an immediate need for the reinstatement of arrangements in the NER that provide for effective frequency control and which support the secure and resilient operation of the national electricity system. In the absence of advice from AEMO that this immediate need has been met through other means, the Commission intends to proceed with the assessment of the *Mandatory primary frequency response* rule change request as a priority.

The AEMC welcomes and thanks the AEC for suggesting the trial. We note that AEMO has outlined a proposal for staged implementation of this rule change request. Should AEC members wish to volunteer as first movers in this staged approach, then this would be appreciated.

The costs of providing PFR

Many stakeholders consider that the costs of providing PFR are not insubstantial and vary for individual generators. Stakeholders argue that mandating PFR provision without valuing PFR based on the different costs incurred by generators to provide PFR distorts competition in the energy markets and so PFR should be appropriately valued.

CS Energy, Stanwell and Delta Electricity identify that thermal generators experience costs related to thermal inefficiencies, where fuel usage increases to maintain stored energy for PFR provision.[50] Delta Electricity quantifies the cost of maintaining 10% headroom for a coal unit:[51]

> The 10% stored energy is known to equate to about 0.9% additional coal consumption. Based on nominal conditions and present coal tonnage costs, this equates to about $1M p.a. per 660MW unit.

Tilt Renewables expects that the ongoing costs incurred by semi-scheduled generators will be greater than those incurred by scheduled generators as semi-scheduled generators typically operate at full output with no headroom and so will mostly provide lower PFR, resulting in lost energy revenue. Tilt Renewables estimates the loss of energy generation due to the mandatory PFR requirement will: [52]

> ...likely to be in excess of 1% of NEM generation revenues, assuming the current frequency performance in the NEM.

A number of stakeholders have expressed that requiring narrow band PFR provision will likely see large costs for batteries due to increased cycling causing substantial wear and tear. [53] Infigen in particular notes that a battery's warranty typically allows for it to cycle once a day,

50 Submissions to the consultation paper: CS Energy, p. 9, Delta Electricity, p. 32, Stanwell p. 6.
51 Delta Electricity, Submission to the *PFR rule changes* consultation paper, 31 October 2019, pp. 32-33.
52 Tilt Renewables, Submission to the *PFR rule changes* consultation paper, 31 October 2019, p. 2.
53 Submissions to the consultation paper: Infigen, p. 2, Enel X, pp. 3-6, Stanwell p. 4.

yet being required to provide PFR continuously can absorb 17.4% to 55% of a 10MW/10MWh battery's warranty limit on energy throughput due to PFR alone.[54]

In general, many stakeholders acknowledge that generators experience different wear and tear costs and opportunity costs dependent on operational and contractual particulars.[55]

A number of stakeholders, including CS Energy, Delta Electricity and Stanwell, consider that, in lieu of a payment for PFR provision, generators would recover the costs of PFR through the energy markets, increasing the energy costs paid for by consumers.[56] Providers of PFR would experience greater costs of energy provision than generators that are not frequency responsive, placing PFR providers in a worse competitive position and creating perverse incentives to avoid providing PFR. [57]

Economically efficient levels of PFR

Many stakeholders do not believe that all generators need to provide PFR for effective frequency control and to obligate all to do so would result in an oversupply of PFR, the inefficient costs of which would be borne by consumers. Some stakeholders have suggested that the required volume of PFR may be much less than a near universal provision:

- Tesla points to the UK's *Enhanced Frequency Response* service to which the National Grid (UK ISO) attributed significant economic benefits from the procurement of 200MW of frequency response services. [58]
- ARENA considers the required volume of PFR to meet system needs is likely to be similar to current regulation FCAS volumes.[59]
- Stanwell argues that AEMO observed a clear improvement in system frequency performance following the PFR trials in Tasmania where approximately 30% of generators had reduced or removed deadbands. Stanwell recognises the Tasmanian power system is different to the mainland power system but believes the trials provide evidence that universal PFR is not required.[60]

ERM Power, Delta Electricity and Energy Australia suggest that an effective mechanism for frequency control should be assessed by its ability to meet the FOS, as defined by the Reliability Panel. Designing a mechanism to meet requirements beyond the FOS raises questions as to whether the level of PFR being procured is necessary and cost-efficient.[61]

Appropriate economic signals for investment and to value innovation

A majority of stakeholders commented on the need for economic signals to encourage investment and innovation in frequency control provision, including investment in batteries,

54 Infigen, Submission to the *PFR rule changes* consultation paper, 1 November 2019, pp. 3-5.
55 Submissions to the consultation paper: Neoen, p. 4, Tilt Renewables, p. 3, CS Energy, p. 2-4.
56 Submissions to the consultation paper: Delta, p. 23, Stanwell, p. 4, CS Energy, p. 2-4.
57 Snowy Hydro, Submission to the *PFR rule changes* consultation paper, 31 October 2019, p. 4.
58 Tesla, Submission to the *PFR rule changes* consultation paper, 31 October 2019, p. 4.
59 Tesla, Submission to the *PFR rule changes* consultation paper, 1 November 2019, p. 2.
60 Stanwell, Submission to the *PFR rule changes* consultation paper, 31 October 2019, pp. 4-5.
61 Submissions to the consultation paper: ERM Power, p. 2, Delta Electricity, p. 6, Energy Australia, p. 2.

FFR provision and demand-side response from DER and VPPs. The mandatory requirement for PFR does not properly value faster frequency control or other frequency services and distorts the FCAS markets, potentially leading to a higher cost for consumers over the long-term. [62]

Stakeholders such as Delta Electricity, Infigen and AGL agree with the point made in the AEMC's consultation paper that the mandatory PFR requirement will lead to increased supply into the contingency FCAS markets, putting downwards pressure on contingency FCAS prices.[63] ARENA, Powershop, AGL and HydroTasmania also expect that the mandatory requirement will reduce the need for regulation frequency control and therefore undermine the price signals in the regulation FCAS markets as well.[64]However, AEMO believes the impact of additional PFR provision on the regulation FCAS markets to be minimal.[65] ARENA notes that decreased FCAS prices would result in reduced costs to consumers in the short-term.[66]

Most stakeholders are concerned that the lack of economic signals for frequency control services will increase the costs of frequency control over time. The two main reasons for this sentiment are:

- There may be an under supply of PFR and other frequency control services without sufficient investment by new entrants, especially as thermal generators retire.[67]
- The proposed arrangements will not incentivise innovation and investment in more cost-effective frequency control technologies.[68]

To expand on the latter point, stakeholders like Energy Australia and Tesla consider that frequency control though demand-side response, such as from DER or through VPPs, should be valued and incentivised through a market or incentive-based mechanism.[69] Enel Green Power supports the importance of new technologies being involved in frequency control in the NEM: [70]

> In the context of an anticipated progressive phase out of conventional thermal generation, EGP considers it important that the proposed rule change does not crowd out the potential of new technologies to provide innovative and cost-effective solutions for managing frequency on the network.

In particular, a number of stakeholders have highlighted that preserving investment signals and value streams for battery technologies is especially important for the long-term efficiency of the NEM. Among others, Enel X, Origin and Neoen consider that batteries will become increasingly important in the future power grid for the provision of a suite of system services

62 Submissions to the consultation paper: Tesla, pp. 6-9, Tilt Renewables, p. 1, Energy Australia, p. 6, Origin, p. 2, IES, p. 2.
63 Submissions to the consultation paper: Delta Electricity, p. 2, Infigen p. 2, AGL, p.4
64 Submissions to the consultation paper: Hydro Tasmania, p. 2, ARENA, p. 2, AGL, p.4, Powershop, p.2.
65 AEMO, Removal of disincentives to the provision of primary frequency response Electricity rule change proposal, 1 July 2019, p. 43.
66 Arena, Submission to the *PFR rule changes* consultation paper, 1 November 2019, p. 2.
67 Submissions to the consultation paper: ERM Power, p. 8, Alinta, pp. 2-3, Stanwell, p. 4, Neoen, p. 5, Enel X, pp. 6-7.
68 Submissions to the consultation paper: Energy Australia, p. 6, Origin, p. 2, Neoen, pp. 1-4.
69 Submissions to the consultation paper: Energy Australia, p. 6, Tesla, pp. 6-9.
70 Enel Green Power, Submission to the *PFR rule changes* consultation paper, 4 November 2019, p. 2.

including firming capacity.[71] Fluence also makes the point that batteries are high performing providers of PFR that provide the service at a lower cost than traditional generators, so increased investment in batteries would decrease the costs to consumers of frequency control.[72] To mirror this, the AEC highlights that sufficient investment in batteries may remove the need for less flexible generation to provide PFR over time.[73]

However, stakeholders consider that an appropriate mechanism for valuing frequency control services would need to be developed to support investment in batteries and emphasises that the impact of the mandatory PFR requirement on FCAS markets damages the current value streams for the technology.[74]

> Neoen is strongly concerned about the negative impact of implementing mandatory PFR requirements on the development of new technologies, particularly batteries, which could be able to offer PFR service with the highest quality standards (speed and accuracy).
>
> [Meridian Energy] also expect that the regulation Frequency Control Ancillary Services (FCAS) markets, particularly the raise FCAS market, will be significantly impacted by the introduction of the proposed rule change and that this will have a material impact on the commerciality of both existing and proposed generators, particularly BESS.

Headroom must be valued for a mechanism to be effective

Without mandatory headroom, or an incentive for generators to preserve headroom, stakeholders have suggested that the mandatory requirement for PFR may not result in effective frequency control.

Energy Australia, for one, does not believe AEMO will be able to rely on the provision of PFR under the *Mandatory primary frequency response* rule as AEMO cannot be certain of the amount of headroom generators are voluntarily providing. [75] Furthermore, due to the costs of preserving additional headroom for frequency control, as discussed above, many stakeholders consider that the mandatory requirement for PFR will incentivise generators not to retain headroom or decommit, unless enabled for FCAS.[76] Stanwell is supportive of this view and considers that, under the proposed mandatory requirement, PFR will only be provided by generators enabled for contingency FCAS or which preserve headroom for fast ramping capabilities.[77]

Some stakeholders consider that the loss of voluntary headroom under the mandatory PFR requirement will result in less PFR being provided than if the rule were not made. Some stakeholders are also concerned that a narrow band PFR requirement will result in the

71 Submissions to the consultation paper: Enel X, p. 1, Origin, p. 2, Neoen, p. 4
72 Fluence, Submission to the *PFR rule changes* consultation paper, 31 October 2019, pp. 1-4
73 AEC, Submission to the *PFR rule changes* consultation paper, 31 October 2019, p. 8
74 Submissions to the consultation paper: Meridian Energy, p. 4, Neoen, p. 1
75 Energy Australia, Submission to the *PFR rule changes* consultation paper, 31 October 2019, pp. 7.
76 Submissions to the consultation paper: ERM Power, p. 8, Delta Electricity, p. 5, AEC, p. 6, Infigen, p. 7
77 Stanwell, Submission to the *PFR rule changes* consultation paper, 31 October 2019, p. 5

headroom that is preserved by generators being utilised for control within the NOFB and therefore not being available for contingency response.[78] Enel Green Power also makes the point that VRE's do not typically have headroom to provide raise PFR, yet the penetration of VRE's is continuing to increase.[79]

Stakeholders consider that an effective frequency control mechanism would incentivise the preservation of headroom for PFR, as summarised by the AEC: [80]

> Confidence in frequency response can only come about if the PFR is supported by a known quantity of stored energy. In turn, this can only come about through dispatched, compensated provision, ideally co-optimised with the energy markets similarly to the existing FCAS markets.

3.3.2 Proposed pathways – Delta Electricity and CS Energy

Delta Electricity and CS Energy, in their submissions to the consultation paper, each proposed alternative pathways to the development and implementation of a payment mechanism for PFR, including proposed intermediate steps.[81]

Delta Electricity

Delta Electricity proposed a set of actions for the development of a market-based mechanism for PFR consisting of five steps:[82]

1. Establish a voluntary trial of tightened deadbands by willing AEC members to be facilitated by the AEMC, AER and AEMO by mid-December 2019.
2. Rule changes and review are completed by the AEMC and the Reliability Panel to redefine the expected quality of frequency control for the NEM.
3. Develop and consult on revisions to the MASS and relevant AEMO operating procedures to include provision of PFR through the existing regulating services.
4. Settlements through FCAS contribution factors remain as currently designed.
5. Modification to monitoring and reporting frameworks to be revised as needed and AEMO should issue market notices accordingly.

CS Energy

CS Energy sets out three possible pathways towards the implementation of a deviation pricing mechanism, supported by a wide deadband (±0.5Hz) mandatory requirement as safety net for major frequency disturbances. CS Energy's pathways consider three stages of policy development: [83]

78 Submissions to the consultation paper: Powershop, p. 4, AEC, p. 6, Infigen, p. 7
79 Enel Green Power, Submission to the *PFR rule changes* consultation paper, 4 November 2019, pp. 1-2
80 AEC, Submission to the *PFR rule changes* consultation paper, 31 October 2019, p. 7
81 Submissions to the consultation paper: Delta Electricity, pp, 32-36, CS Energy, pp. 20-26
82 Delta Electricity, Submission to the *PFR rule changes* consultation paper, 31 October 2019, pp. 34-36
83 CS Energy, Submission to the *PFR rule changes* consultation paper, 31 October 2019, pp. 20-26

- **Immediate term -** The introduction of a mandatory requirement for PFR, preferably with a wide deadband, to address the immediate concern of system resilience to major frequency disturbances.
- **Short-term -** The implementation of a new or modified framework to incentivise the provision of PFR within the NOFB in the interim before a deviation pricing mechanism can be developed. CS Energy's three pathways each consider alternative short-term mechanisms based on the introduction of a new two-sided causer pays mechanism for PFR or a modification of the current Contingency FCAS market.
- **Long-term -** Any tight-band mandatory requirement is widened to (nominally) ±0.5Hz and a "pay-and-paid-on performance marginal price incentive" mechanism, like deviation pricing, is introduced as the enduring solution for procuring frequency control services.

To determine how the costs or payments for PFR may be calculated, CS Energy also presents work done in conjunction with IES to determine an "Efficient Cost" estimate for lower and raise PFR for any particular generator. These costs are determined from a calculated system need for PFR (ACE-Reg) and the addition of the opportunity costs of a generator preserving headroom and the costs of utilising this headroom. CS Energy provides analysis to support that the estimation of "Efficient Costs" for each generator can be calculated 'live' using four second data as the spot price and quantity of raise and lower PFR required by the system vary over time.[84]

The Commission recognises the potential utility of the PFR valuation approach that CS energy and IES have developed. The Commission intends to consider the development of an effective valuation and payment mechanism for PFR through the assessment of the *Removal of disincentives to the provision of primary frequency control* rule change.

3.4 The draft revised frequency control work plan

The final report for the *Frequency control frameworks review* established a frequency control work plan. The frequency control work plan provides a vehicle for:

1. the AEMC and AEMO to implement the various actions in the work plan below, and report on progress against those actions
2. the AEMC to further explore, and seek stakeholder input on, potential longer-term mechanisms for the procurement of a primary regulating response and other frequency services as the needs of the power system evolve.
3. the AEMC to consider, and consult with stakeholders on, how the frequency requirements in relation to the maintenance of a satisfactory operating state are specified in the NER and the frequency operating standard, which will include consideration of whether the NER or the frequency operating standard should:
   a. include a system standard in relation to the rate of change of power system frequency.

84 CS Energy, Submission to the *PFR rule changes* consultation paper, 31 October 2019, pp. 22-24

b. prescribe in more detail the required frequency performance within the normal operating frequency band.

This draft determination includes an updated draft revised Frequency control work plan that reflects the work completed to date by the market bodies and highlights future actions to be undertaken as part of an ongoing reform pathway, provided in Table 3.1. The Commission invites stakeholder feedback on the content and time frames set out in the draft revised work plan and intends to finalise the revised work plan next year.

3.4.1 Objectives

At a high level, the objectives for the frequency control work plan are that:

- the expected frequency performance of the power system is specified in the Frequency operating standard,
- AEMO has adequate tools to control system frequency in accordance with the requirements of the Frequency operating standard,
- the obligations and incentives on market participants support the efficient investment in and operation of the national electricity system.

3.4.2 Principles

The actions detailed in the frequency control work plan are guided by the National Electricity Objective (NEO). In considering any changes to the regulatory and market frameworks, the Commission will consider whether the change is likely to support and improve the security of the power system along with the effectiveness and efficiency of frequency control frameworks. In particular, it will be guided by the following principles:

- **Promotes system security as a priority -** The operational security of the power system relates to the maintenance of the system within pre-defined limits for technical parameters such as voltage and frequency. System security underpins the operation of the energy market and the supply of electricity to consumers. Consideration will be given to the impact on system resilience and the ability to plan and model the power system. The Commission will have regard to the potential benefits associated with improvements to system security brought about by the proposed rule changes, weighed against the likely costs.
- **Appropriate risk allocation -** The allocation of risks and the accountability for investment and operational decisions should rest with those parties best placed to manage them. The arrangements that relate to frequency control should recognise the technical and financial capability of different types of market participants to respond to changes in frequency. Where practical, operational and investment risks should be borne by market participants, such as businesses, who are better able to manage them.
- **The requirement that system frequency performance is specified in the Frequency operating standard** - The Frequency Operating Standards specifies, with the appropriate detail, the expected frequency performance of the power system. As the frequency control arrangements are revised to reflect the changing needs of the power

system, the frequency operating standard may require updating to reflect the expectations for power system frequency control.

- **Efficient investment in, and operation of, energy resources to promote secure supply**: The market and regulatory arrangements that relate to frequency control should result in efficient investment in, and operation of, energy resources to promote a secure supply of electricity for consumers. The frequency control frameworks should also seek to minimise distortions in order to promote the effective functioning of the market. In the case of the arrangements for frequency control, market participants should be encouraged to invest in and operate plant in a way that supports the control of system frequency.
- **Technology neutral:** Regulatory arrangements should be designed to take into account the full range of potential market and network solutions. They should not be targeted at a particular technology or be designed with a particular set of technologies in mind. Technologies are changing rapidly, and, to the extent possible, a change in technology should not require a change in regulatory arrangements.
- **Flexibility:** Regulatory arrangements must be flexible to changing market and external conditions. They must be able to remain effective in achieving security outcomes over the long-term in a changing market environment. Where practical, regulatory or policy changes should not be implemented to address issues that arise at a specific point in time. Further, NEM-wide solutions should not be put in place to address issues that have arisen in a specific jurisdiction only. Solutions should be flexible enough to accommodate different circumstances in different jurisdictions. They should be effective in facilitating security outcomes where required, while not imposing undue market or compliance costs.
- **Transparent, predictable and simple:** The market and regulatory arrangements for frequency control should promote transparency and be predictable, so that market participants can make informed and efficient investment and operational decisions. Simple frameworks tend to result in more predictable outcomes and are lower cost to implement, administer and participate in.

3.4.3 The draft revised frequency control work plan

The frequency control work plan has been developed collaboratively by the AEMC and AEMO. The dates associated with each action are intended to provide indicative guidance to stakeholders.

The work plan is intended to be a living document and will be further shaped by the findings of each stage as it is progressed. In addition, the market bodies are working closely with the ESB on its *Post-2025 Market Design* project. This project will advise on a long-term fit for purpose market framework to support reliability, modifying the NEM as necessary to meet the needs of future diverse sources of non-dispatchable generation and flexible resources including demand side response, storage and distributed energy resource participation.

The ESB published an issues paper in September for its *Post-2025 Market Design* project. This included discussion of key challenges for system security services such as the fact that the frequency of the power system is now at risk of not meeting the standard and, more

importantly, is now showing inadequate response to disturbances that would normally be expected. The market bodies are working closely with AEMO on these issues.

The AEMC will continue to consult with key stakeholders through the technical working group that was established for the purpose of assessing the primary frequency response rule change requests. The working group will provide a valuable means for the AEMC and AEMO to gain input and feedback on the progress and activities related to the objectives of the frequency control work plan.

As requested by AEMO, the immediate steps include the implementation of a mandatory requirement for scheduled and semi-scheduled generators to provide PFR to support frequency control in the NEM in the interim. Through this workplan the AEMC and AEMO commit to the development and implementation of enduring frequency control frameworks. This includes future changes to the NER to provide for an incentive-based mechanism for the provision of PFR to support effective frequency control in the national electricity system prior to June 2023.

The frequency control work plan is set out in Table 3.1.

Table 3.1: **The draft revised frequency control work plan**

TIMING	ACTION
COMPLETED These actions were completed between 26 July 2018 and the time of publication of this draft determination, 19 December 2019.	
December 2018	AEMO published a revised causer pays procedure that promotes clarity and removes intervals where the frequency indicator (FI) and actual frequency are mismatched and publishes FI data closer to real time.
April 2019	Reliability Panel published a final determination on stage two of the *Review of the frequency operating standard*, which included a thorough review of the settings contained in the standard.
May 2019	Through a two-month trial of increased regulation FCAS volumes from October to December 2018 in the mainland NEM, AEMO investigated the need to increase the quantity of regulating FCAS on a static or dynamic basis. From March 2019 to May 2019 AEMO progressively increased the base quantity of mainland NEM regulation FCAS volumes from 130/120MW to 220/210 MW raise/lower.
July 2019	The Commission made a final rule, *Monitoring and reporting on frequency control framework,* which established ongoing reporting requirements: • on AEMO in relation to frequency and frequency control performance; and • on the AER in relation to the performance of frequency control ancillary services (FCAS) markets. The rule will commence on 1 January 2020.
August 2019	AEMO assessed the effectiveness of its short-term actions at meeting the requirements of the frequency operating standard and communicated a need to implement interim measures before a longer-term mechanism for primary frequency control within the normal operating frequency band comes into effect. In August 2019, AEMO submitted a rule change request to implement a mandatory PFR requirement to address the immediate security needs of the power system.
November 2019	AEMO commenced consultation on proposed changes to Market ancillary service specification and the Causer Pays procedure. The proposed changes are intended to facilitate the provision of primary frequency response

TIMING	ACTION
	under normal operating conditions.
Late 2019	AEMO made adjustments to AGC tuning as part of the upgrade of its energy management system software.
IMMEDIATE TERM (PRESENT - DECEMBER 2020) During this period, AEMO continues with a range of actions to better understand the current and future frequency control needs of the power system and takes steps towards addressing these needs through a revision of current AEMO operating practices and procedures. This period also contains the AEMC's assessment of the *Mandatory primary frequency response* rule change and the *Removal of disincentives to primary frequency response* rule change. The AEMC is focused on the implementation of a mandatory requirement for scheduled and semi-scheduled generators to provide PFR to support frequency control in the NEM in the interim through the *Mandatory primary frequency response* rule change. However, through the *Removal of disincentive to primary frequency response* rule change the AEMC will consider approaches to incentivising and rewarding the provision of frequency control services that can be put in place on an enduring basis. This will also be an input into the ESB's post 2025 market design work.	
Ongoing	AEMO commissioned a further review of AGC systems in July 2019, which may result in further adjustments to AGC tuning.
Ongoing	AEMO, the AEMC and the AER established a NEM virtual power plant trial program in November 2018 to support an understanding of the technical and regulatory requirements associated with virtual power plants providing FCAS, as well as energy and network support services. This work will inform AEMO's review of the MASS and the AEMC's ongoing work on removing barriers to distributed energy resources participating in wholesale markets.
Ongoing	AEMO continues its review of contingency FCAS quantities, including: • The staged reduction of NEM load relief factors • Review of maximum switch reserve quantity • Consideration of regional FCAS requirements • Minimum technical requirements for Regulation FCAS As of November 2019, AEMO has reduced the assumed mainland load relief from 1.5% to 1.0% and will

TIMING	ACTION
	continue to reduce load relief to 0.5% by mid-December.
Ongoing	AEMO reports on the outcomes of the actions set out above as results become available through its Ancillary Services Technical Advisory Group, Frequency Control Working Group and/or published reports.
December 2019	The AEMC publishes the draft determination on the consolidated *Mandatory primary frequency response* and *Primary frequency response requirements* rule changes.
1 January 2020	Commencement date for the *Monitoring and reporting on frequency control framework* rule. AEMO produces frequency performance reports on a weekly and quarterly basis, as required by the new rule. AER produces FCAS market performance reports on a quarterly basis, as required by the rule.
Q2 2020	AEMO evaluates the requirement to submit a rule change request to: • allow Small Generation Aggregators to classify small generating units as market ancillary service generating units for the purposes of providing market ancillary services, and • to clarify that Market Ancillary Service Providers are able to satisfy their obligations to provide market ancillary services through enabling small generating units. This action will be informed by the outcomes of the NEM virtual power plant trial program described above.
From Q1 2020	AEMO continues its work on assessing the longer-term needs of the power system, based on a holistic view of inertia, primary and secondary frequency control as well as potential new needs. AEMO is to consider issues such as: • Ability to cover coincidental ramps in VRE Ramps • Locational and temporal requirement for faster contingent frequency response • The role of advanced inverter capabilities AEMO's assessment will consider the system needs under various operating conditions, as well as the available technology capabilities during this time. This analysis will determine the characteristics of the frequency services that will be required and inform the development of service specifications for

TIMING	ACTION
	market/incentive-based mechanisms. The co-optimisation of these service specifications with energy dispatch will also be considered. AEMO will work with market participants to trial capabilities under these anticipated network conditions. AEMO will update their progress on this work through staged reporting in relevant publications.
March 2020	AEMO's intended completion of its review of the *Market ancillary service specification* and implementation of changes to the parameters for valuation of the relevant market ancillary services to support the delivery of primary frequency response under normal operating conditions when the system frequency is with the normal operating frequency band.
March 2020	AEMO's intended completion of its review of the Causer pays procedure to align with proposed changes to the NER through its rule change request, *Removal of disincentives to primary frequency response*. Timing subject to change, pending outcome of the AEMC's assessment of the *Removal of disincentives to primary frequency response* rule change request.
26 March 2020	Expected AEMC publication of a final determination on the consolidated *Mandatory primary frequency response* and *Primary frequency response requirements* rule changes.
April - May 2020	Scoping phase for potential solutions to the issues raised in the *Removal of disincentives to primary frequency response* rule change request – stakeholder engagement to include meeting with the technical working group for the Primary frequency response rule changes.
4 June 2020	Proposed commencement for the substantive elements of the *Mandatory primary frequency response* rule.
September 2020	Expected AEMC draft determination on the *Removal of Disincentives to Primary frequency response* rule change request. This will include consideration of approaches to incentivise and reward the provision of frequency control services.[1]
December 2020	AEMO's intended commencement of proposed changes to generator governor settings for the second tranche of generators (generators <200MW) under the *Mandatory primary frequency response* rule.
December 2020	Expected AEMC final determination on the *Removal of Disincentives to Primary frequency response* rule change request.[1]

TIMING	ACTION
Q4 2020	AEMO reports on the requirement to add or amend performance objectives for frequency control in the NEM

OTHER RELATED WORK

In addition to the above, as noted earlier, AEMO, the AER, the ESB and the AEMC are all working together in coordination with the ESB's *Post-2025 Market Design* plan. Part of this work includes looking at issues to do with system security and resilience, including such key challenges as:

- Identify which additional services may be required given the changing mix of supply with more asynchronous generation
- Determine how the market can efficiently procure the system services needed, valuing those services in ways which drive both the investment needed and their efficient delivery
- Provide incentives to minimise the cost of those services and provide for innovation and new technology in their provision

The development of frequency control markets and frameworks through this work program will therefore need to be undertaken coherently with the ESB's work. As per the *Post-2025 Market Design Forward Work Program,* the ESB is scheduled to develop the rule changes required to implement its recommended changes to existing market design throughout 2021 with finalisation of these changes by 1 July 2022.

Throughout this period, AEMO continues monitoring and reporting on power and generation system behaviour, which informs the work of all market bodies on enduring solutions for frequency control.

Note: 1 - These are preliminary dates for the assessment of the *Removal of Disincentives to Primary frequency response* rule change request. The scope and timing of this process will be confirmed in 2020 following the publication of a final rule for Mandatory primary frequency response.

OVERVIEW OF THE DRAFT RULE

This chapter provides an overview of the draft rule, which is a more preferable draft rule, including the introduction of a mandatory PFR requirement for all scheduled and semi-scheduled generators who have received a dispatch instruction to generate a volume greater than 0 MW to operate their plant in accordance with the P*rimary frequency response requirements* as applicable to that plant. The draft rule includes provisions for the mandatory requirement to commence on 4 June 2020 and be removed after a period of three years on 4 June 2023.

As described in Chapter 3, this draft determination is part of the Commission's ongoing frequency control work plan. Through the work plan, the Commission will work with the ESB and other market bodies to implement enduring frequency control arrangements that support a secure and resilient power system while providing adequate incentives to encourage economically efficient investment in and operation of generation plant in the NEM.

The following sections provide an overview of the key elements of the draft rule including:

- the mandatory PFR requirement
- the process for exemption or variation to the performance parameters for the provision of PFR
- the arrangements for implementation of the mandatory PFR requirement
- other changes to the NER that relate to the provision of PFR by market participants in the NEM.

The Mandatory PFR requirement

The draft rule places an obligation on all scheduled and semi-scheduled generators who have received a dispatch instruction to generate a volume greater than 0 MW, to operate their plant in accordance with the performance parameters set out in the *Primary frequency response requirements* as applicable to that plant. AEMO is responsible for the development of the *Primary frequency response requirements* in consultation with market participants.

The following sections provide an overview of the Commission's draft determination for:

- the mandatory requirement for all scheduled and semi-scheduled generators to provide PFR
- the specification of the technical requirements for PFR

Further detail on the Commission's considerations in relation to the introduction of the mandatory PFR requirement, and its analysis and considerations of submissions received, are set out in Appendix A.

4.1.1 A mandatory requirement for all scheduled and semi-scheduled generators

The Commission's draft rule includes a requirement in Chapter 4 of the NER that all registered scheduled and semi-scheduled generators who have been given a dispatch

instruction to generate to a volume greater than 0 MW be required to comply with the PFRR.[85] AEMO has advised the AEMC that this reform will meet the immediate system need for effective frequency control in the NEM.

The Commission considers this change to the NER is justified by the need to improve and maintain the security and resilience of the national electricity system to meet AEMO's concerns, but also recognises that the draft rule will not adequately value or reward frequency response from capable generating units. The Commission considers that in the longer term there should be incentives and rewards for providing primary frequency response. Schedule 2 of the draft rule effectively applies a sunset to the mandatory obligation on generators to provide PFR by reversing the changes made to the rules to introduce the mandatory framework on 4 June 2023. This creates a clear signal that the Commission is committed to the development of an arrangement that appropriately incentivises primary frequency response provision to be put in place prior to the sunset.

A lower bound on the deadband to be set out in the NER

The draft rule introduces a new *primary frequency control band* of 49.985Hz to 50.015Hz (or such other range as specified by the Reliability Panel in the frequency operating standards), which sets a lower bound on the deadband to which individual generators must comply under the PFRR. The Commission considers that the *primary frequency control band* is a key variable associated with the draft rule, which has implications for both system operation and the operation of the markets for electricity and ancillary services in the NEM. In the absence of a clearly defined frequency performance standard in the FOS, the Commission has determined that the minimum bound for the *primary frequency control band* be specified in the NER, and not subject to full discretion by AEMO in the PFRR.

No requirement to maintain additional stored energy

The Commission has also specified in the draft rule that the PFRR cannot require generators to maintain additional stored energy for the purposes of providing frequency response in accordance with the requirements of the PFRR. The Commission acknowledges that AEMO does not propose to include a requirement in the PFRR that generators maintain headroom (stored energy) as part of its proposed rule. However, the PFRR is subject to change, and any future obligation which results in a large cross-section of the generating fleet maintaining stored energy would likely impose substantial costs on generators that outweigh the additional benefits this might provide to the security of the power system. This aspect of the draft rule will provide greater clarity and certainty to generators and will limit the likelihood of substantial unwarranted costs being incurred by generators in the future.

Treatment of battery energy storage systems

In response to stakeholder concerns in submissions to the consultation paper, the Commission has considered the impact of a mandatory PFR requirement on the operation of

85 The Commission will be recommending to the COAG Energy Council that this requirement be classified as a civil penalty provision under the National Electricity (South Australia) Regulations. The Commission's draft rule would result in most generators with a nameplate rating less than 30MW not being required to provide PFR unless registered as a scheduled or semi-scheduled generator.

battery energy storage systems. Under the draft rule, when generating (discharging), battery energy storage systems will be treated the same as other scheduled and semi-scheduled generators and will be required to provide PFR in accordance with the conditions set out in the PFRR. When operating in a charging mode, battery energy storage systems will be treated the same as other scheduled loads, which are not required to provide PFR.

However, unlike other generation technologies, battery energy storage systems are capable of providing a frequency response when they are neither charging or discharging, ie neither supplying nor consuming energy from the grid. Under the draft rule, generators that are not dispatched in the energy market to generate electricity are not required to operate in a frequency response mode in accordance with the PFRR. As such, the draft rule includes a provision that generators are only required to provide PFR when they have received a dispatch instruction to generate at a volume greater than 0 MW. The Commission considers that the application of the mandatory PFR requirement to battery energy storage systems that are not dispatched to generate electricity would be discriminatory, as other generation technologies cannot provide PFR unless they are online and generating.[86]

4.1.2 The specification of the technical requirements for PFR

The draft rule includes a requirement for AEMO to develop and publish the *Primary frequency response requirements* to specify the performance parameters that apply to generators in respect of the provision of PFR. AEMO submitted to the Commission an initial draft of the PFRR for consideration alongside its rule change request. AEMO has informed the Commission that it will consult with stakeholders and take into account stakeholder feedback provided through the rule change process in refining this document. AEMO will also need to update the draft PFRR to reflect this draft rule. The transitional provisions in the draft rule require AEMO to publish a draft interim PFRR by 9 April and then consult on this draft, before finalising the interim PFRR by 4 June 2020. The finalised document will form the interim PFRR, which will be adapted and refined over time. AEMO is also required under the draft rule to make the first PFRR required under new clause 4.4.2A(a) of the Rules by 1 December 2021. Any changes to the PFRR after this date must be undertaken through the Rules consultation procedures.

The draft rule introduces a new clause 4.4.2A(b) which requires that the PFRR include:

- A requirement that Scheduled Generators and Semi-Scheduled Generators set their generating systems to operate in frequency response mode within one or more primary frequency response performance parameters (which may be specific to different types of plant), including: maximum allowable deadbands; droop; and response time.
- The conditions or criteria on which a generator may request and AEMO may approve a variation or exemption from any applicable primary frequency response parameters, and the process and timing for an application for a variation or exemption.
- Details of information to be provided to AEMO to verify compliance with the PFR.

86 This is consistent with the approach taken by the US Federal energy regulatory commission in its 2018 ruling on Primary frequency response. Ref. RM16-6-000, pp.126 - 127.

With respect to the PFRR, the draft rule includes provisions that:

- AEMO must follow the Rules consultation procedures to make any substantive change to the PFRR.
- AEMO must publish and maintain on its website a register of generators who have been granted a variation or exemption from the performance parameters set out in the PFRR.

4.2 Exemptions from the PFR requirement

The draft rule includes an exemption framework that is based on the approach set out in AEMO's proposed rule. The draft rule introduces a new clause 4.4.2A(b)(2) which requires that the PFRR include provision for Generators to request, and AEMO to approve, an exemption or variation from the requirements specified by AEMO in the *Primary frequency response requirements* applicable to their generating system. AEMO is the appropriate party to consider the exemptions since they are the system operator and so have the technical information required to assess both costs, as well as the effect that the exemption would have on frequency performance.

The draft rule also introduces a new clause 4.4.2B which sets out the following criteria which AEMO must have regard to in considering such a request:

(1) the capability of the generating system to operate in frequency response mode;

(2) the costs that are likely to be incurred in augmenting the generating system to be able to operate in a frequency response mode relative to the turnover derived from, and the expected operating hours, of the generating system in relation to its operation in the *national electricity market*;

(3) the stability of the generating system when operating in a frequency response mode and the potential impact this may have on power system security;

(4) the ongoing costs of operating the generating system in frequency response mode; and

(5) any other physical characteristics of the generating system which may affect its ability to operate in frequency response mode, including (but not limited to) dispatch inflexibility profile, operating requirements, or energy constraints.

The Commission expects that the costs for each generator to meet the performance parameters for PFR will vary. Some generation plant are likely to meet the performance parameters for PFR with minimal need for plant changes. The capability from these generators can be utilised for a relatively low upfront implementation cost.

Other generation plant may require more significant plant upgrades and control system tuning in order to provide PFR in accordance with the technical requirements. In the absence

of an exemption framework some generators could be forced to incur substantial costs for plant upgrades to comply with the PFR requirement.

An effective exemption framework can introduce a degree of flexibility that avoids excessive compliance costs for eligible generation plant while still delivering on the system security and frequency control objectives. The proposed exemption framework provides for this flexibility while at the same time setting out a series of principles to improve the transparency of the exemption process and making sure that the immediate system security requirements are met.

Consistent with AEMO's proposed rule, the draft rule also introduces a new clause 4.4.2A(d) to require that AEMO publish on its website, and maintain, a register of generators who have been granted an exemption or variation from any primary frequency response parameters in the PFRR.

Further detail on the Commission's considerations in relation to the framework for exemption or variation to the technical requirements for mandatory PFR and its analysis and considerations of submissions received are included in Appendix B.

4.3 Implementation and transitional arrangements

The draft rule includes transitional provisions that set out the arrangements for the implementation of the mandatory PFR requirement. The transitional rules in chapter 11 of the NER include a requirement for AEMO to prepare interim *Primary frequency Response requirements* to apply from 4 June 2020 (which is the date the provisions that introduce the mandatory framework will commence). AEMO has confirmed with the AEMC that it is comfortable with this date.

In addition to the performance parameters for the provision of PFR, the interim *Primary frequency response requirements* also document AEMO's process for coordinating changes to generation plant associated with activation of the frequency response mode as intended by the *Mandatory primary frequency response* rule. This process would also include the date by which each generator must comply with the performance parameters set out in the *Primary frequency response requirements*.

The Commission acknowledges stakeholder concerns in relation to the coordination of plant changes associated with the implementation of the mandatory primary frequency response requirement. In particular, stakeholders have expressed concern that the hasty or uncoordinated implementation of changes to generator control systems may pose risks to generation plant and power system security due to the proposed deadband of ±0.015Hz being untested in the history of the NEM. To address these concerns, the draft rule requires AEMO to publish a draft of the interim *Primary frequency response requirements* by 9 April 2020 (which can take into account the final rule), and provide stakeholders at least 20 business days to make submissions on the draft. AEMO is required to take into account any submissions received, and to develop and publish on its website interim *Primary frequency response requirements* by 4 June 2020.

AEMO may undertake consultation prior to the commencement date of the rule

The Commission recognises that AEMO has identified the reinstatement of effective frequency control through the mandatory PFR requirement as a system security priority to be implemented in the shortest reasonable time frame.[87] Given the potential consequences of the ongoing lack of effective frequency control in normal operating conditions, the Commission has made a draft rule that includes allowance for AEMO to commence consultation on the interim *Primary frequency response requirements* prior to the commencement date for the amending rule. While the actual timings of the consultation process are a matter for AEMO, the draft rule would require that the interim *Primary frequency response requirements* is finalised and published on AEMO's website prior to the commencement date for the mandatory primary frequency response requirement on 4 June 2020.

Consideration of reimbursement for upfront costs

AEMO's proposed rule included transitional arrangements for Generators to submit a claim for reimbursement of costs associated with plant upgrades to become compliant with the *Primary frequency response requirements*, and for AEMO to recover its associated costs through participant fees.[88]

Compensation is not typically provided to affected parties for the costs associated with complying with an amendment to the NER. Furthermore, the costs for plant upgrades and control system changes are expected to be relatively minor and manageable for most affected generators. Where the costs of plant upgrades are more substantial, it is intended that a generator will be eligible for a full or partial exemption from the requirement which will avoid or reduce the upfront costs.

Therefore, the draft rule:

- does not include any transitional arrangements for affected generators to be directly reimbursed for plant upgrade costs;
- does not include any transitional arrangements for AEMO to recover such associated costs through market participants fees.

Further detail on the Commissions considerations in relation to the process and timing for the implementation of the mandatory PFR requirement and its analysis and considerations of submissions received are included in Appendic C.

Other proposed changes

AEMO and Dr. Sokolowski each proposed a number of other changes to the NER that relate to the provision of PFR. The Commission's conclusions on each of these proposed changes are set out below.

- **Clause 3.15.6A(k) — Contribution factors for the allocation of costs for regulating services**

87 AEMO, Mandatory Primary Frequency Response - Electricity rule change proposal, 16 August 2019, p.41.

88 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, pp. 61-65.

The draft rule revises NER clause 3.15.6A(k)(5) and 3.15.6A(k)(7) to clarify that a scheduled participant or a semi-scheduled generator will not be assessed as contributing to deviations in the frequency of the power system if within a dispatch interval it achieves its dispatch target at a uniform rate subject to the provision of PFR by that Participant in accordance with the PFRR.

- **Clause 4.9.4 — Dispatch related limitations on generators**

  The draft rule includes changes to clause 4.9.4(a)(3), including the addition of clause 4.9.4(a)(3A) stating that both scheduled and semi-scheduled generators may send out energy as a consequence of its operation in a frequency response mode to adjust power system frequency in response to power system conditions.

- **Clause 4.9.8 — Compliance with a dispatch instructions**

  The draft rule includes changes to clause 4.9.8 to clarify that operating a plant in a frequency response mode is compatible with a generators' obligation to follow its dispatch instructions. In particular, new clause 4.9.8(a1) states that a scheduled Generator or Semi-scheduled Generator would not be taken to have failed to comply with a dispatch instruction as a consequence of its generating unit operating in frequency response mode in order to adjust power system frequency in response to power system conditions.

- **Clause S5.2.5.11 — Generator technical performance standards for frequency control**

  The draft rule includes a clarificatory note after S.5.2.5.11(b)(2) and S5.2.5.11(c)(2) that provides additional clarity in relation to the operational requirement for frequency control as set out in the draft rule clause 4.4.2(c1). The note states that:

  - Clause 4.4.2(b) of the Rules sets out the obligations on Generators in relation to compliance with the technical requirements in S5.2.5.11, including being capable of operating in frequency response mode
  - Clause 4.4.2(c1) of the Rules sets out the obligations on Scheduled and Semi-Scheduled Generators in relation to the *Primary frequency response requirements*.

- **Clause S5.2.5.14 — Generator technical performance standards for active power control**

  The Commission considers Dr. Sokolowski's proposed change to S5.2.5.14 does not provide a benefit in terms of improving the specification or clarity of the frequency control capability for connecting generators. As such, the draft rule does not amend S5.2.5.14.

Dr. Sokolowski also proposed changes to certain clauses in the rules relating to system security more generally, including proposed changes to:

- **NER Clause 4.3.1 — AEMO's responsibilities for maintaining power system security**

  The Commission notes AEMO has an existing obligation to maintain and improve power system security under S49(1)(e) of the NEL. The NEL requirement is also referenced in

the NER clause 4.1.1(b). In the context of the existing obligations, the proposed change does not constitute a material benefit in terms of the understanding or the application of the NER.

The draft rule does not include any revision to NER clause 4.3.1.

- **NER Clause 5.20B.5 —inertia support activities and the definition of inertia**

  Clause 5.20B.5(a) of the NER allows for frequency control services, from inverter connected plant or otherwise, to be considered as 'inertia support activities' subject to approval by AEMO. The Commission notes that the existing arrangement for inertia support activities are inclusive of fast frequency response from inverter connected plant under the term, frequency control services. Therefore, the Commission does not consider there to be a benefit in making the proposed change by Dr. Sokolowski to clause 5.20B.5(a).

  The Commission considers that the existing definition of inertia reflects the current operational practice that differentiates between physical inertia provided by synchronous machines and fast frequency response provided by inverter connected plant. The proposed change would remove that distinction and result in inertia being a more general term that included any plant that is able to oppose a change in power system frequency.

  The draft rule does not include any change to Clause 5.20B.5 nor to the Chapter 10 definition of inertia.

Further detail on the Commission's considerations in relation to the other proposed changes to the NER and its analysis and considerations of submissions received is included in Appendix D.

ABBREVIATIONS

AC	Alternating current
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AGC	Automatic generation control system
Commission	See AEMC
DC	Direct current
DNSP	Distribution network service provider
DRP	Dispute resolution procedure
EFCS	Emergency frequency control scheme
FCAS	Frequency control ancillary service
Hz	Hertz
MASS	Market ancillary service specification
MCE	Ministerial Council on Energy
NEL	National Electricity Law
NEMDE	National electricity market dispatch engine
NEO	National electricity objective
NERL	National Energy Retail Law
NERO	National energy retail objective
NGL	National Gas Law
NGO	National gas objective
NOFB	Normal operating frequency band (49.85 Hz — 50.15 Hz)
OFGS	Over frequency generation shedding scheme
PFR	Primary frequency response
TNSP	Transmission network service provider
UFLS	Under frequency load shedding scheme

A A MANDATORY REQUIREMENT FOR ALL GENERATORS TO PROVIDE PRIMARY FREQUENCY RESPONSE

The Commission has made a draft rule, which is a more preferable rule, to place an obligation on all scheduled and semi-scheduled generators to provide primary frequency response in accordance with the requirements of AEMO's *Primary frequency response requirements* (PFRR). AEMO is responsible for the development of an interim and then the ongoing PFRR in consultation with market participants. The requirement for all scheduled and semi-scheduled generators to provide primary frequency control is informed by expert advice from both the system operator.

It would be possible for eligible generators to obtain an exemption from this requirement or a variation of the PFRR in relation to its generating system, which is discussed in Appendix B.

This appendix explores the application of a mandatory obligation on all scheduled and semi-scheduled generators to provide primary frequency response and sets out further detail on the Commission's draft rule in relation to:

- the requirement under chapter 4 of the NER for scheduled and semi-scheduled generators to comply with the requirements of the PFRR when they receive a dispatch instruction to generate to a level above 0 MW
- the required content of the PFRR to be developed by AEMO
- the inclusion of a new *primary frequency control band* in Chapter 10 of the NER which defines the minimum deadband to which AEMO could prescribe on an individual generator through the PFRR
- the inclusion of a provision in chapter 4 of the NER to clarify that the PFRR cannot require generators to maintain headroom as a condition of complying with the requirements of the PFRR
- interactions with generator performance standards.

A.1 Mandating PFR requirement to achieve a desired frequency performance in the power system

The Commission's more preferable draft rule:

- creates an obligation on each Scheduled Generator and Semi-Scheduled Generator to operate its generating system in accordance with the PFRR as applicable to that generating system
- clarifies that compliance with the above obligation does not require a Scheduled Generator or Semi-Scheduled Generator to maintain additional stored energy in its generating system for this purpose
- creates an obligation on AEMO to develop and publish the PFRR in accordance with the Rules consultation procedures

- sets out the content of what the PFRR must include

A.2 Proponents' views

A.2.1 AEMO's views

Mandatory primary frequency response

In its rule change request AEMO proposes that the obligation to provide PFR apply to all technically capable generating systems registered to participate in the NEM. AEMO's rationale for this approach is that it would:[89]

- reduce the frequency response burden and related costs on each individual generating unit
- provide geographic diversity of frequency response and increase system resilience to contingency events
- assist AEMO's efforts to accurately model the power system and plan for contingency events
- align the operation of the NEM with international best practice for power system operation.

AEMO acknowledges that the implementation of a mandatory PFR requirement would result in eligible generation plant incurring both upfront costs and ongoing costs in order to comply with this obligation.[90] However, AEMO considers that these costs are expected to be significantly less than the costs associated with the risks to system security that are associated with the continuation of poor frequency control in the NEM as well as the potential for further degradation in the absence of some requirement for increased PFR.

AEMO's proposal is supported by advice provided to AEMO by Dr. John Undrill that an obligation to provide PFR should apply to all generating systems, to the extent that it is practical to do so.[91] Dr. Undrill notes that this approach is intended to be a conservative and prudent approach to maintaining system security and resilience within a power system that is undergoing rapid technological transformation.

AEMO's proposed rule seeks to require all capable scheduled and semi-scheduled generating units to provide PFR once frequency moves outside a defined frequency band. AEMO suggests that effective control and resilience of the power system would be achieved with a narrow response deadband. AEMO suggests that the allowable deadband be set at ±0.015Hz, which would align power system outcomes in the NEM with standard international practice and provide a stable basis for the ongoing transformation of the generation mix in the NEM.[92] Therefore, as soon as frequency moves above, or below 50 Hz by 0.015Hz the generators would automatically provide PFR.

89 AEMO, Submission on the consultation paper, pp.3-4.
90 AEMO, Mandatory primary frequency response - Electricity rule change proposal, 16 August 2019, pp. 55-59.
91 Dr. John Undrill, Notes on Frequency Control for the Australian Energy Market Operator, 5 August 2019, p. 3
92 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, p. 46.

In particular, AEMO considers that a narrow response deadband would:[93]

- result in the most stable control of frequency under normal operating conditions and would reduce the amplitude of the observed ongoing oscillations in NEM frequency to the lowest practicable level.
- maximise the resilience of the NEM to frequency disturbances by minimising the frequency deviation caused by any given power system disturbance, which would provide the best opportunity of maintaining stable operation of the power system.

AEMO's rule change request does not specify a quantified frequency performance outcome rather it is based on the operational goal of requiring primary frequency response in relation to a narrow deadband from all capable generation plant.

AEMO considers that this approach is the best way to address existing power system frequency issues. AEMO notes in its rule change request that alternatives are not feasible:

- narrowing the normal operating frequency band (NOFB) in the FOS would not deliver effective frequency control in the absence of the development of an effective tool to control frequency during normal operation.[94]
- revising the FOS and introducing a new market or performance-based mechanism at this time is also not appropriate, as such a policy approach would lead to a delayed implementation of a solution to the immediate power system frequency issues.

Application of obligation

AEMO does not propose to apply a capacity threshold as to which generators would be required to provide primary frequency response. However, AEMO suggests that the requirements should only apply to scheduled and semi-scheduled generators, which effectively limits the obligation to generators with capacity greater than 30MW.

AEMO's proposed rule includes changes to clause 4.4.2 of the NER to require all scheduled and semi-scheduled generating units and generating systems to be responsive to frequency outside of a defined frequency deadband.

Primary Frequency Response Requirements

Under AEMO's proposed rule, the maximum allowable frequency response deadband, along with other technical characteristics would be determined by AEMO and specified in a new document, the Primary Frequency Response Requirements (PFRR). AEMO would prepare the PFRR in accordance with the rules consultation procedures.[95]

AEMO's rule change request provides an overview of the technical performance parameters that it intends to specify in the PFRR.[96] AEMO provided an update to the draft PFRR in October 2019. AEMO proposed technical performance parameters are set out in Box 2 below.

93 Ibid.
94 AEMO, Mandatory primary frequency response - Electricity rule change proposal, p.39.
95 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, pp. 44-45.
96 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, pp. 44-45

AEMO proposes that the PFRR document would also set out:[97]

- the process by which AEMO would approve a variation or exemption from a performance requirement related to the provision of PFR
- the details of any information to be provided by a generator and audits or tests that may be conducted to verify compliance with the requirement
- the process for undertaking tests to demonstrate compliance with the PFRR
- the process for eligible generators to seek compensation

AEMO's rule change request indicates that it does not intend to prescribe requirements for the following technical criteria associated with the provision of PFR:[98]

- **Headroom** — there is no proposal for any requirement for additional headroom or energy reserve — any generating plant that is unable to raise output in response to falling frequency, or lower output in response to rising frequency due to a lack of available headroom, will not be deemed as non-compliant.
- **Minimum droop** — there is no proposal for a minimum droop requirement.

Further detail on the content of AEMO's proposed PFRR is set out in Box 1.

AEMO also proposes that the generator performance standards under S5.2.5.11 in the NER be amended to remove any potential ambiguity with respect to the PFRR. This would make clear that generators are required to meet the requirements of the PFRR. In order to make it clear, the generator performance standards would be amended to remove the requirements in relation to the capability to set droop and deadband settings. In addition, it would be made clear in the access standards such that compliance with the standards would be 'subject to the *primary frequency response requirements*'.

AEMO considers that the capabilities required under the draft PFRR are not more onerous than the access standards in clause S5.2.5.11, or in other existing minimum access standards in clause S5.2.5.[99]

BOX 2: AEMO'S DRAFT PRIMARY FREQUENCY RESPONSE REQUIREMENTS

AEMO's proposed rule sets out a proposed governance arrangement where the NER would require AEMO to prepare the Primary frequency response requirements and that scheduled and semi-scheduled generators must operate their plant in accordance with the Primary frequency response requirements.

AEMO has prepared a draft of the *Primary frequency response requirements* (PFRR) to detail the technical requirements and application of the mandatory PFR requirement. In October, AEMO provided an update to this initial PFRR, which included some revisions to the technical requirements, exemptions, and testing and modelling components of the PFRR. The following

97 AEMO, Primary frequency response requirements — draft, August 2019, pp. 6-8
98 Ibid
99 AEMO, Submission on the consultation paper, pp.6-7.

is a summary of AEMO's revised PFRR, which can be found on our website.

Technical Requirements

AEMO describes the active power modulation that constitutes PFR and details the proposed parameters of the required response, including that:

- there is no requirement to maintain additional headroom or stored energy for the provision of PFR,
- the maximum deadband outside of which generators must provide PFR is to be ±0.015Hz,
- the droop setting that dictates the amount of active power change for a change infrequency beyond the deadband, measured as a percentage of a generator's maximum operating level, is to be less than or equal to 5 per cent,
- the speed of response should be such that a 5 per cent change in active power is achieved in no more than ten seconds,
- the response should not be deliberately withdrawn or defeated until the power system frequency returns to within the deadband, subject to plant capability,
- a generator should not use plant controls to limit PFR if it can be safely and stably delivered, recognising a generator's operational ranges such as minimum and maximum operating levels,
- PFR must remain continuously enabled with consistent settings unless otherwise agreed with AEMO.

Application

The draft PFFR sets out a proposed process for Generators to demonstrate to AEMO their compliance with the technical requirements, including:

- The requirement and time frame for generators to conduct and submit to AEMO a self assessment of technical capabilities to comply with the PFRR. For Generators with nameplate capacity greater than 200MW, this is to be completed within 60 business days from commencement of the PFRR. Other generators are allowed 120 business days.
- AEMO's ability to request further information within five days if it deems the information provided by a generator to be insufficient. Generators must provide the requested information within five days of the request.
- AEMO's response to Generator self-assessments, to be provided within 20 days of receipt. AEMO will acknowledge generators that meet the Technical Requirement or will liaise with the Generators that will need to modify their plant regarding control settings, scope of modification work and time frames.
- A prohibition to initiate any modifications of plant to meet the Technical Requirements prior to AEMO's response and agreement.
- Generators may apply for an extension of the specified due date to complete plant modifications. AEMO will consider and respond to such requests within 20 business days.

- Generators must apply to AEMO to make changes to their agreed control settings. AEMO will consider and respond to such requests within 20 business days.

Exemptions

AEMO recognises that some generators may not be inherently capable of providing PFR and so may need to seek exemption from the requirements stipulated in the PFRR. Therefore, the draft PFRR includes the following information on seeking exemptions and standing exemptions:

- A plant may be eligible for exemption from the PFRR if it cannot be modified, or requires significant augmentation, to provide PFR.
- A plant may be eligible for partial exemption from the PFRR if AEMO determines that full compliance with one or more of the Technical Requirements would affect power system security.
- A plant must submit its application for an exemption to AEMO, with reasons and supporting evidence, within the time frames stipulated above for a plant's self–assessment of technical capabilities.
- AEMO may request further information within ten days if it deems the information provided by a generator to be insufficient. Generators must provide the requested information within ten days of the request.
- Standing exemptions for the steam turbine components of CCGT plant and for plant when operating in synchronous condenser mode.

Testing and modelling

Generators that make changes to their plant and plant control systems will be required by AEMO to undertake the appropriate tests to demonstrate compliance with the PFRR and any other relevant standards depending on the extent of the changes.

At a minimum, the draft PFRR states that any change to a control system or primary plant will require a step response stability test that tests the response of the plant to a step change infrequency of ±5 per cent.

Any changes beyond plant load controllers will require the generator to test its plant in accordance with the requirements of AEMO's GPS Compliance Assessment and R2 Model Validation Test Plan Template.

Publication

The draft PFRR requires AEMO to publish and maintain a list of generating plant containing the details of their PFRR exemption or compliance status.

Compensation for implementation costs

AEMO outlines in the draft PFRR which plant is eligible for compensation and the process for generators to seek compensation:

- Generating plant that have an existing connection agreement and need to alter their plant to meet the Technical Requirements are eligible to recover the costs directly and reasonably incurred to modify the plant.
- AEMO provides examples of compensable and non-compensable costs.
- Generators must submit an application for compensation using the form in Appendix C of the PFRR
- AEMO details the supporting evidence required for compensation of implementation costs and may request further information if necessary.
- AEMO will advise Generators of the outcome of their application within 30 business days. If AEMO determines the costs of modifying a plant to be uneconomic, AEMO may grant the plant exemption from the PFRR.
- A generator may agree or dispute the outcome of their application for compensation.
- AEMO will pay the compensation agreed or awarded to an Affected Generator within 20 business days of receipt of the relevant documentation.

Submission Forms

AEMO's draft PFRR includes the following proposed appendices:

- a form for a Generator's self-assessment of technical capability.
- a form for a Generator to apply for an exemption from the PFRR.
- a form for a Generator to apply for compensation of implementation costs.

Source: AEMO, Primary frequency response requirements - Revised draft, October 2019.

A.2.2 Dr. Sokolowski's views

Dr Sokolowski's rule change request also proposes a mandatory obligation that would be implemented through the NER and be intended to apply to all registered generation in the NEM.

Dr Sokolowski proposes to introduce a mandatory PFR requirement that is implemented through changes to Schedule 5.2 of the NER. Schedule 5.2 of the NER sets out the technical performance requirements that a generating system must satisfy as a condition of connection to the power system.[100]

Dr Sokolowski's proposed rule includes new sub paragraphs (g) and (h) under cl S5.2.5.11 which are set out as mandatory requirements. The proposed new rules clauses are:

1. Each synchronous generating unit must have enabled and responsive speed governor systems with deadbands no greater than 50 mHz (to avoid doubt +25 mHz to -25 mHz) providing primary frequency control and maintaining nominal

100 Dr Sokolowski, Primary frequency response requirement — Electricity rule change proposal, 30 May 2019, pp.17-24.

rotational speed of the generating unit in steady state conditions and contribute to system response for contingency events.

2. Asynchronous generating systems must have enabled frequency droop control with deadbands no greater than 50 mHz (to avoid doubt +25 mHz to -25 mHz) providing frequency response in steady state conditions and contribute to the system response for contingency events.

Beyond the frequency response deadband, Dr Sokolowski's proposed rule does not specify any other technical criteria for PFR.

A.3 Stakeholders' views

A mandatory approach versus an incentive-based or market-based approach

In submissions on the AEMC's consultation paper, the majority of stakeholders acknowledged the need for more effective control of power system frequency as identified by AEMO.[101] However, stakeholders held a diversity of views on the most appropriate means of addressing these issues.

A number of stakeholders suggested that a mandatory approach is likely to provide more PFR than is necessary and will result in higher costs when compared to a market based approach, which would lead to an economically efficient outcome through individual generator decision-making.[102]

Tesla suggests that a better understanding of the PFR requirements of the NEM is necessary and that it would be beneficial to assess how a small number of generators providing quality PFR (fast response and high accuracy) that is also geographically dispersed, compares against the proposal for broad-based provision from a generating fleet with lower quality PFR.[103]

A number of stakeholders raised concerns that a mandatory approach is not likely to deliver effective outcomes with a changing energy mix. ERM Power suggests that the muting of the price signal through the introduction of mandatory primary frequency response may deter new suppliers from entering the market and influence existing suppliers to exit.[104] Origin considers that new entrants are unlikely to invest in frequency response capability beyond the mandated minimum if there is no financial incentive to do so.[105] Origin suggests that batteries are likely to play an increasingly important role in providing fast frequency response to support system security as synchronous generators exit the market, and incentives will be

101 Submissions on the consultation paper: Bruce Miller, p.1; Kate Summers, p.1; Stanwell, p.2; CS Energy, pp.1-2; Australian Energy Council, p.1; Delta Electricity, p.7; Ergon Energy and Energex, p.1; Fluence, p.2; AGL, p.1; Infigen, p.1; Tesla, p.3; Hydro Tasmania, p.1; Intelligent Energy Systems, p.2; Enel X, p.1; Tilt Renewables, p.1; MEA Group, p.1; Energy Networks Australia, p.1; TasNetworks, p.1; Neoen, pp.1-2; PIAC, p.3; AER, p.1.

102 Submissions on the consultation paper: AER, p. 2; CS Energy, pp. 9-10; ERM Power, p.2; Delta Electricity, p.7; Origin, p.2; ARENA, pp.2-3; EnergyAustralia, p.2; Enel X, p.5; Stanwell, p.5; Snowy Hydro, p.3; Clean Energy Council, p.4; AGL, p.2; Infigen, pp.1-2; Tesla, p.4; Enel Green Power, p.1.

103 Tesla, Submission on the consultation paper, p.3.

104 ERM Power, Submission on the consultation paper, p.11.

105 Origin, Submission on the consultation paper, p.2.

required for this future investment to be provided. This view is supported by Enel X who considers that a mandatory obligation to provide PFR is likely to adversely impact the business case for battery storage, at a time when governments, policy makers, businesses and AEMO are looking to batteries to help resolve multiple market issues.[106]

The Energy Efficiency Council suggests that the proposal would be a significant departure from the current direction of energy markets to use market-based signals and technology neutral approaches, This could have the effect of undermining the energy industry's confidence and increase the perception of the risks of investing in the NEM.[107] The Australian Energy Council also considers that mandating the provision of primary frequency response runs counter to good market principles and that the different levels of service provided by different technologies deserves differential reward.[108]

The Australian Energy Council and Alinta Energy both suggested that, if a mandatory approach is implemented, it should be accompanied by a sunset clause in the NER to be replaced by a more economically efficient approach at a future time.[109] The Australian Energy Council suggests that a sunset clause will force the industry to remain focused on the task and avoid the situation where a replacement has not been developed and implemented before the majority of PFR capability retires.

A number of stakeholders considered that a mandatory approach to the provision of primary frequency response is likely to be a preferred approach.[110] Kate Summers noted that frequency response requires local measurement and local control action and that dynamic response from plant cannot be centrally controlled through market dispatch targets due to communication latencies.[111] Resilience in the power system would be greatly improved through reimplementing tight responsive governor systems that are not overridden by market dispatch instructions. Ergon Energy and Energex suggest that a more robust and resilient power system is likely to result from all generating systems working together.[112]

TasNetworks shared AEMO's concerns in relation to the forward costs likely to be incurred in the absence of measures to better control network frequency.[113] TasNetworks considers that any delay in responding to PFR issues risks increasing uncertainty and reducing network robustness in the face of the NEM's 'world leading' penetration levels of asynchronous generation. This will only inevitably need to be countered with additional future conservatism in the design and operation of the power system, which is not in the long term interests of consumers.

TasNetworks considered there to be arguments in favour of both a mandatory approach and a market based approach.[114] The physical construct of the power system still relies on PFR to

106 Enel X, Submission on the consultation paper, p.1.
107 Energy Efficiency Council, Submission on the consultation paper, p.1.
108 Australian Energy Council, Submission on the consultation paper, p.5.
109 Submissions on the consultation paper: Australian Energy Council, p.9; Alinta Energy, pp.3-4.
110 Submissions on the consultation paper: Kate Summers, p.2; Bruce Miller, pp.1-2.
111 Kate Summers, Submission on the consultation paper, p.2.
112 Ergon Energy and Energex, Submission on the consultation paper, p.1.
113 TasNetworks, Submission on the consultation paper, p.3.
114 TasNetworks, Submission on the consultation paper, p.4.

be available to operate in an acceptable manner. Contributions coming from a dispersed and broad range of providers will likely mean that the real cost of delivering the capability will trend towards something small. On this basis, a market approach may not be justified as long as the NER ensures ongoing capability from new technologies as they are progressively introduced over time. However, a market approach may have the benefit of encouraging investment in technologies or solutions that could deliver a better outcome for the power system in the long term.

Where a mandatory rule is implemented, some stakeholders proposed the application of a regulated payment in advance of the implementation of a more sophisticated remuneration mechanism.[115]

Mandating a requirement for all generators to provide PFR

The majority of stakeholder responses raised concerns that any proposal to mandate the provision of primary frequency response could lead to substantial ongoing costs for generators, and that these costs are likely to vary substantially between different technology types.[116] Neoen suggested that the most responsive assets, such as batteries, will have to bear most of the operational load and will therefore be strongly impacted while slow responsive generation will see little of no consequence.[117] The economic impact on the most responsive plant will therefore be greatly increased.

This view was supported by Alinta Energy and Enel Green Power who considered that a proposal to mandate the provision of PFR would in effect create a perverse situation whereby those generator types which are perhaps best placed to respond will be penalised and those generators who are worst placed to respond will be treated the same for the provision of a potentially inferior level of service.[118]

Neoen considered that a mandatory obligation on all generators would maximise the cost of implementation and acquire PFR from generators with poor capabilities or who would be economically impacted by operating in a frequency sensitive mode.[119]

The adverse commercial and economic impacts of the proposed mandatory PFR requirement are described in the stakeholder submissions from generators and owners of battery energy storage systems and include:[120]

- Responsive generation will face a range of ongoing operational costs without adequate compensation or valuation of services provided

115 Submissions on the consultation paper: Alinta Energy, p.4; Hydro Tasmania, p.2; Energy Australia, p.2.

116 Submissions on the consultation paper: CS Energy, pp.2-4; ERM Power, p.8; Delta Electricity, p.13; Tilt Renewables, pp.1-2; Enel X, pp.5-6; Snowy Hydro, p.3; Enel Green Power, p.1; Intelligent Energy Systems, p.2.

117 Neoen, Submission on the consultation paper, pp.3-4.

118 Submissions on the consultation paper: Alinta Energy, pp.2-3; Enel Green Power, p.1.

119 Neoen, Submission on the consultation paper, p. 3.

120 Submissions on the consultation paper: Neoen, p.1; Origin, p.2; ARENA, p.4; MEA Group, p.2; Australian Energy Council, pp.5-6; Fluence, p.2; Alinta Energy, p.2; Tesla, pp.4-5; Energy Efficiency Council, pp.1-2; Enel X, pp.5-6; Clean Energy Council, p.2; Infigen, p.2-6; Delta Electricity, p.13.

- The absence of an explicit mechanism to value PFR during normal operation may undermine the business case for plant that can provide this type of response most competitively
- The mandatory requirement does not allow for different generating plant to optimise plant performance for the generation of bulk energy and pay a fee for other plant to control frequency (via causer pays or otherwise)

Ongoing operational costs

Stakeholders suggested that the ongoing operational costs of a PFR requirement may include:

- the opportunity costs of providing a primary frequency response,
- the utilisation costs of providing a primary frequency response, including wear and tear and costs of movement enablement.

ERM Power noted that generators incur opportunity costs when preserving capacity to provide a frequency response.[121] Opportunity costs may come in the form of forgone revenue when preserving headroom to provide a raise response when the energy market price is above the generator's marginal cost, or maintain a high output in order to provide a lower response when the energy market price is below the generator's marginal cost.

CS Energy noted that the proposed rule does not require generators to preserve headroom and that this would thereby not impose unnecessary opportunity costs on the cheapest generators.[122] However, both the Australian Energy Council, CS Energy and Stanwell suggested that this could lead to a number of other issues:[123]

- The physical response of the power system will be dependent on opportunistically stored energy, which will be random on the basis of market dispatch and other matters,
- The lack of raise response from most renewable generators will mean that it is likely that generators as a whole will respond much more effectively to high rather than low frequencies, causing a lopsided frequency performance and accumulated time error,
- Generators will have an incentive to avoid the burden of compliance by intentionally operating without stored energy, transferring the burden on to other generators,
- Those generators that are enabled in the contingency FCAS markets will be called upon foremost in the provision of a primary frequency response, which will mean that contingency reserves are drawn upon pre-contingency.

The provision of mandatory primary frequency response will also increase utilisation costs from complying generation plant. Stanwell considered that utilisation costs are incurred in two ways.[124] Firstly, as increased wear and tear which reduces unit efficiency, requiring additional fuel per unit of generation over time, and secondly, as the cost of movement enablement which, for thermal generators, requires generating extra steam pressure in

121 ERM Power, Submission on the consultation paper, p.8.
122 CS Energy, Submission on the consultation paper, p.9.
123 Submissions on the consultation paper: Australian Energy Council, p.6; CS Energy, p.9; Stanwell, p.4.
124 Stanwell, Submission on the consultation paper, p.6.

addition to the steam pressure setpoint maintained to allow ramping to dispatch targets. This higher boiler pressure creates a continuous cost and reduction in efficiency arising from burning fuel to create high pressure steam and then throttling it across a control valve without extracting any valuable energy from it.

Enel X noted that high utilisation costs were the primary motivation for the Carboneras coal-fired plant in Spain to install a 20MW battery facility on site in response to a mandatory requirement to provide PFR.[125] In this case, the battery system is used to provide the frequency response, allowing the main plant to run more efficiently and avoiding wear and tear.

Stanwell also suggested that the burden on batteries from a mandatory approach would also be significant due to the expected increase in cycling which would reduce the operating life.[126]

Infigen explores the impacts on batteries in its submission and suggests that a mandatory approach will represent a material adverse impact that prevents batteries from delivering other more valuable services.[127]

Infigen suggested that there are two principal ways in which a mandatory approach would reduce the investment case for batteries:[128]

- Cycling the battery through its warranty without providing any compensation for the cost of degradation[129]
- Increasing the cost of delivering contingency services from a battery and increasing uncertainty in the future market value of contingency services

Infigen suggested that a battery enabled to provide PFR will respond to all frequency disturbances outside of the narrow deadband.[130] Even when the battery is not operating for energy or regulation dispatch (ie power output is at 0MW) it will still react to frequency changes and provide PFR. The identified difference between a battery and traditional thermal generation is that a battery can be 'always available' to the market even if not enabled for energy or FCAS.

Infigen noted that a mandatory approach would create an incentive for batteries to make themselves unavailable to the market when not operating, thereby reducing system resilience and capacity reserves for PFR.[131]

Market impacts

125 Enel X, Submission on the consultation paper, p.5.

126 Stanwell, Submission on the consultation paper, p.4.

127 Infigen, Submission on the consultation paper, p.3.

128 Infigen, Submission on the consultation paper, pp.3-6.

129 Analysis undertaken by Infigen suggests that, under an assumed frequency distribution similar to that observed in 2005, a one-hour battery delivering contingency FCAS would cycle around 63 times in a year just responding to PFR, thereby reducing the warranty of the battery by up to 17% over the lifetime of the battery. For a 15-minute battery, this would extend to 254 cycles in a year, using 70% of the warranty. Infigen, Submission on the consultation paper, p.5.

130 Infigen, Submission on the consultation paper, p.3.

131 Infigen, Submission on the consultation paper, p.2.

An expected impact on FCAS markets was also noted in a number of stakeholder submissions.[132] The Australian Energy Council suggests that a mandatory requirement for generators to respond will mean that the marginal cost of being enabled for the provision of FCAS falls to zero, which in turn will distort traders' composition of their offers in the contingency FCAS markets. AGL suggested that generator will look to the energy market to recover the revenue lost in the FCAS market, which will see higher prices for consumers.

Requirement to maintain headroom

Delta Electricity considered that a mandatory obligation on all generators to provide primary frequency response, without either a requirement or being paid to maintain headroom, would potentially reduce the overall headroom that is being provided by NEM participants when not enabled in the contingency FCAS markets.[133] This potential reduction in headroom represents a risk that a greater system security condition will arise. Delta Electricity considered it likely that the requirement for headroom will need to be revisited following the implementation of the proposed mandatory approach, and that it would be preferable for this to be undertaken through the rules framework.[134]

Stanwell suggested that the assumption under a mandatory approach that generators would have natural headroom available would overly burden some generators as semi-scheduled technologies will only provide a raise response if pre-curtailed.[135] Furthermore, if no natural headroom is available, the only generators that would respond would be contingency FCAS providers. These concerns were shared by the Australian Energy Council who suggested that a reliance on opportunistically stored energy may lead to a reduced, rather than greater, level of confidence in the power system.[136]

Stakeholder submissions also suggested that if a mandatory requirement is implemented, then the requirement not to maintain stored energy or headroom to comply with this requirement be set out in the NER to provided certainty for market participants in relation to this key variable.[137] Stanwell considered that the costs associated with maintaining headroom are substantial and that any future considerations in respect should go through an AEMC-led consultation process.[138] The Clean Energy Council considered that clarity is particularly important for solar generators who need to ensure this exclusion would protect their right to generate at full capacity and as such only provide lower services in this instance.[139]

Deadband setting

There are a range of views as to the appropriate frequency response dead band for a wide band mandatory PFR requirement, with frequency response deadbands ranging from

132 Submissions on the consultation paper: Australia Energy Council, pp.7-8, AGL, p.4; Stanwell, p.4.
133 Delta Electricity, Submission on the consultation paper, p.5.
134 Delta Electricity, Submission on the consultation paper, p.14.
135 Stanwell, Submission on the consultation paper, pp.4-5.
136 Australian Energy Council, Submission on the consultation paper, p.6.
137 Submissions on the consultation paper: Delta Electricity, p.14; Stanwell, p.6; Australian Energy Council, p.7.
138 Stanwell, Submission on the consultation paper, p.6.
139 Clean Energy Council, Submission on the consultation paper, p.4.

±0.015Hz as proposed by AEMO through to ±0.5Hz as supported by a number of generators.[140]

The Commission notes that a number of generators are supportive of a mandatory requirement that only applies outside of a wider frequency response band such as ±0.5Hz.[141] This support is based on the understanding that the commercial impacts of providing sporadic frequency response to contingency events are relatively small (without the need to reserve headroom and incur the related opportunity costs). These generators have also indicated an acceptance that generator response following large contingency events provides a common benefit by maintaining system integrity. Delta Electricity considers that a wider deadband of control mandated on all participants would provide a safety net when unexpected conditions arise.[142]

The Australian Energy Council suggested that a more appropriate means of increasing the resilience of the power system is likely to be a combination of more robust FCAS Contingency Services specification and procurement, supported by a backstop governor requirement with a very wide deadband at ±0.5Hz.[143]

However, there is considerably more debate in relation to the proposed requirement for all generators to provide PFR outside of a narrow frequency response deadband close to 50Hz and inside of the NOFB. Many generators have indicated that this proposal will result in material additional operating costs on an ongoing basis. EnergyAustralia suggested that more work should be done to determine whether ± 0.015Hz is a sensible deadband before implementing a mandatory approach, noting that this narrow deadband is unprecedented in Australia.[144]

ERM Power and Delta Electricity both suggested if a greater degree of frequency response is required then the Reliability Panel, in consultation with stakeholders, should determine the adequate quality of frequency control in the NEM and be responsible for amending the FOS as required.[145]

The AER considered that the determination of specifications set out in the PFRR may be better suited to the Reliability Panel given its role in determining the standards required to deliver a secure power system.[146]

Compliance

The AER suggested that some challenges may arise in implementing and monitoring a mandatory obligation on generators and that this could lead to additional upfront and ongoing costs.[147]The AER is concerned that a requirement for generator to comply with the

140 Submissions to the consultation paper: Australian Energy Council, p.7; CS energy, p.5; ERM Power, p.2.

141 Submissions to the consultation paper: Australian Energy Council, p.3; CS Energy, p.5; ERM Power, p.7; Delta Electricity, p.7; Infigen, p.2.

142 Delta Electricity, Submission on the consultation paper, p.7.

143 Australian Energy Council, Submission on the consultation paper, p.3.

144 EnergyAustralia, Submission on the consultation paper, p.5.

145 Submissions on the consultation paper: ERM Power, p.9; Delta Electricity, p.6.

146 Australian Energy Regulator, Submission on the consultation paper, p.3.

147 Australian Energy Regulator, Submission on the consultation paper, p.2.

conditions of the PFRR would mean that the PFR characteristics of each generator would need to be recorded in order to assess compliance and that this may require the installation of high speed monitoring equipment for verification purposes, and associated protocols for data retention.

A.4 Commission's analysis

BOX 3: SUMMARY OF DRAFT RULE

The Commission's draft rule includes introducing a requirement in Chapter 4 of the NER that all registered scheduled and semi-scheduled generators who have received a dispatch instruction to generate at a volume above 0 MW be required to comply with the PFRR.[1] AEMO has advised the AEMC that this reform will meet the immediate system need for effective frequency control in the NEM. AEMO's opinion is supported by technical advice received from AEMO's consultant, Dr John Undrill.

The draft rule introduces a new *primary frequency control band* of ±0.015 Hz (or some other range as specified by the Reliability Panel in the power system security standards) outside of which scheduled and semi-scheduled generators must provide PFR. This would set a lower bound on the deadband to which individual generators must comply under the conditions of the PFRR. The Commission considers that the *primary frequency control band* is a key variable associated with the draft rule, which has implications for both system operation and the operation of the markets for electricity and ancillary services in the NEM. In the absence of a clearly defined frequency performance standard in the FOS, the Commission has determined that the minimum bound for the *primary frequency control band* be specified in the NER, and not subject to full discretion by AEMO in the PFRR.

The Commission has also specified in the draft rule that generators are not required to maintain additional stored energy as a condition of complying with the requirements of the PFRR. The Commission acknowledges that a requirement in the PFRR that generators maintain stored energy was not part of AEMO's proposed rule. However, the PFRR is subject to change, and any future obligation which results in a large cross-section of the generating fleet being required to maintain stored energy would likely impose substantial costs on generators that are likely to outweigh the additional benefits this might provide to the security of the power system. This aspect of the draft rule will provide greater clarity and certainty to generators and will limit the likelihood of substantial unwarranted costs being incurred by generators in the future.

Unlike other generation technologies, battery energy storage systems are capable of providing a frequency response when they are neither charging or discharging, ie neither supplying nor consuming energy from the grid. Under the draft rule, generators that are not dispatched in the energy market to generate electricity are not required to operate in a frequency response mode in accordance with the PFRR. As such, the draft rule includes a provision that generators are only required to provide PFR when they have received a

dispatch instruction to generate at a volume greater than 0 MW.

All other specifications of the technical criteria for providing primary frequency response would be determined by AEMO in consultation with market participants and set out in the PFRR. The draft rule requires that the PFRR must include the following:

- a requirement that Scheduled Generators and Semi-Scheduled Generators set their generating systems to operate in frequency response mode within one or more primary frequency response performance parameters (which may be specific to different types of plant), including: maximum allowable deadbands; droop; and response time;
- the conditions or criteria on which a generator may request and AEMO may approve a variation or exemption from any applicable performance parameters
- details of information to be provided to AEMO to verify compliance with the PFRR

The Commission's draft rule will result in most generators with a nameplate rating less than 30MW being not required to comply with the PFR requirement (unless they are registered as a scheduled or semi-scheduled generator). Generators will also only be required to provide PFR when dispatched above 0 MW in the energy or ancillary services markets. In addition, AEMO may approve an exemption or variation to the requirement to provide PFR for specific generating plant which is technically incapable of complying with the requirements of the PFRR. This is aspect of the draft rule is described further in appendix B.

The Commission considers that in the long term it would be better to incentivise generators to provide primary frequency response. Given the time associated with developing such arrangements it is not possible to do this in time to address the immediate system security needs. Further work also needs to be undertaken to understand the power system requirements for good frequency control. Therefore, the draft rule includes a sunset to the mandatory primary frequency response requirement. This creates a clear signal that the Commission is committed to the development of an arrangement that appropriately incentivises primary frequency response provision to be put in place prior to the sunset.

In accordance with the sunset, the mandatory approach will be in place for a three-year period, expiring in June 2023. The Commission considers that it is possible to develop and implement a long-term approach in this time which creates incentives for providing primary frequency response. This also places a discipline on the market to focus on longer-term solutions that are sustainable in the longer-term.

[1] The Commission will also propose that this requirement be classified as a civil penalty provision under the National Electricity (South Australia) Regulations.

A.4.1 A mandatory requirement for all scheduled and semi-scheduled generators

A mandatory obligation to apply to scheduled and semi-scheduled generators

The nature of a mandatory obligation is to require all scheduled and semi-scheduled generators to provide a primary frequency response in accordance with a pre-defined set of

conditions. Since the nature of the obligation is mandatory, while there could be some variations in the requirements placed on different generators, it is inevitable that some generators would be better equipped than others when it comes to providing a primary frequency response.

The Commission considers this immediate change to the NER is justified by the need to improve and maintain the security and resilience of the national electricity system to meet AEMO's concerns. AEMO's views, which were informed by their consultant Dr. John Undrill, are that all of the generation fleet needs to provide primary frequency response in order to be effective in managing system security concerns. The key recommendation provided in Dr. Undrill's advice to AEMO is that:[148]

> The obligation to provide primary control response to variations of frequency should be applied to the widest practical part of the generating fleet. The obligation should apply, to the extent that it is practical, to all generating resources including those that are coupled to the grid through electronic inverters.

Given the need for an immediate change to the NER to restore effective frequency control in the NEM, the Commission accepts AEMO's proposal that primary frequency response should be required from all capable generating systems in the NEM with a capacity of more than 30 MW. This approach will deliver broad-based provision of PFR and is expected to fulfil the objectives defined by AEMO in its rule change request.

The Commission recognises stakeholder concern that a requirement for *all* generators to provide primary frequency response outside of a narrow frequency response deadband close to 50Hz could result in additional operating costs on an ongoing and upfront basis. Further, that these costs are likely to impact generators differently depending on their capability and technology. These ongoing costs could include direct utilisation costs of providing the response through increased wear and tear and resource consumption; as well as the opportunity costs of foregoing alternative revenue through the energy market.

Despite this, the Commission accepts AEMO's view, informed by its consultant Dr. John Undrill, that a broad application of the mandatory approach would mean that costs incurred by each *individual* generator would be minimised. If every scheduled and semi-scheduled generator is required to provide primary frequency response then this will minimise the costs for each individual generator, since no one generator will bear the burden of responding - instead, this will be shared across the entire fleet. In other words, the costs associated with introducing the requirement on *all* generators are likely to be cheaper in total compared with the outcome where only some generators were required to provide primary frequency response.

In addition, given that all generators will be required to provide primary frequency response, similar costs will be imposed on each generator. Given that the wholesale market is competitive, this means that the generators will all be able to recover their costs through adjusting their energy market offers, and so in turn, wholesale energy market prices.

148 Dr. John Undrill, Notes on frequency control for the Australian Energy Market Operator, 5 August 2019, p.3.

Wholesale electricity prices will reflect the necessary cost of providing primary frequency response in order to manage system security. Obviously, it will be harder for generators with higher costs than the marginal generator, and those that are lower in the merit order to recover their costs through the energy market. However, the Commission considers that this is likely to be manageable.

This is supported by AEMO's case study of PFR in the Wholesale Energy Market (WEM) in Western Australia which provides evidence that a mandatory obligation applied to a broad cross-section of the generating fleet minimises the primary frequency response required to be provided by each individual generator.

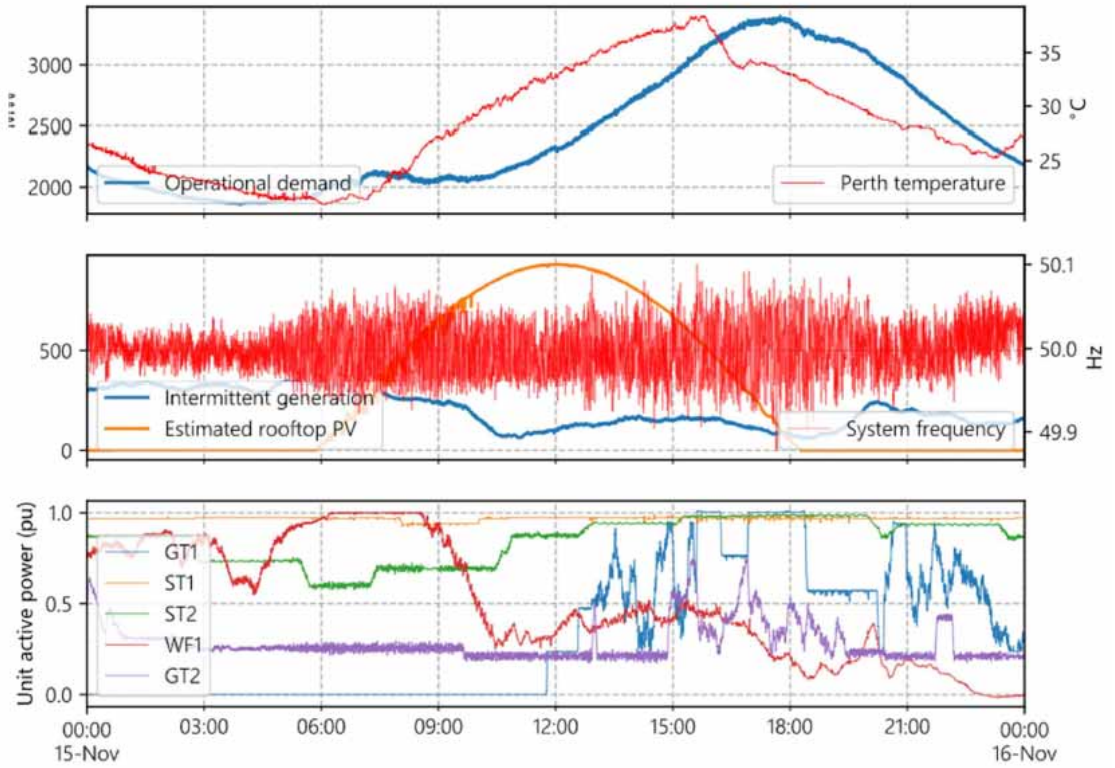
WEM Primary Frequency Response Case Study

AEMO recently undertook a case study to look at the impacts of the mandatory requirements in the Wholesale Electricity Market (WEM) in Western Australia. The case study examined a one-week snapshot of various conditions and describes the standards and behaviour of generators supporting frequency control.

Figure A.1 is taken from a 24-hour period during the week and shows

- system operational demand and ambient temperature in Perth
- system frequency, total wind farm output and estimated total output from rooftop PV
- active power output of various anonymised units operating in accordance with the PFR requirements

Figure A.1: WEM system operation 15-16 November 2019



Source: AEMO, WEM Primary Frequency Response Case Study

A key observation from the figure is that ST1 and ST2, which are both thermal coal units providing PFR, generally do not move far from their basepoints, with variation only a very small fraction of output (typically ~1%). Further information on AEMO's case study is contained in an attachment to this draft determination which is available on the AEMC project page.

Sunset provisions

The Commission also expects that a mandatory primary frequency response requirement would drive increased participation in the contingency FCAS markets, which would put downward pressure on prices for these services in the short-term, lowering prices for consumers. The Commission notes that FCAS revenue is a dominant revenue stream for new sources of generation such as demand response providers, market ancillary service providers and battery energy storage systems. These new technologies are a critical source of FCAS capability as thermal generation plant retires.

Additionally, the Commission is aware of stakeholder concerns in relation to the potential for the mandatory PFR requirement to dampen the available incentives for providing frequency control through the markets for FCAS. While AEMO has indicated that it does not intend to reduce the quantity of contingency reserve services that it procures as a consequence of this

rule, it is expected that the mandatory PFR requirement will drive increased participation in the FCAS markets, which will increase competition and put downward pressure on prices for these services. The Commission recognises that the evolution of the FCAS markets has not kept pace with the system requirements for frequency control and that the implementation of mandatory PFR is now required to support the secure operation of the power system. The Commission considers that further work needs to be done to understand the power system requirements for maintaining good frequency control and to reform the existing frequency control frameworks to meet these needs now and in the future.

The Commission therefore considers this change to the NER is justified by the need to improve and maintain the security and resilience of the national electricity system to meet AEMO's concerns, but also recognises that the draft rule will not adequately value or reward frequency response from capable generating units. For example, passing the cost of primary frequency response through the energy market does not reveal the extent of these costs to the market and places the costs directly on consumers rather than recovering the costs through the FCAS markets. Generators are therefore not exposed to the full costs of managing system frequency through causer pays and thereby have little incentive to minimise any adverse impacts on frequency.

Therefore, the Commission considers that in the long-term there would be benefits in incentivising parties to provide primary frequency response. This requires more thought and development and so could not be put in place to address immediate concerns, or, at least would be more costly than the approach outlined in this draft rule.

As discussed in chapter 3, further refinements to the NER in relation to valuation and remuneration of frequency response will be considered through the assessment of AEMO's *Removal of disincentives to the provision of PFR* rule change request.

Therefore, the Commission has also introduced a sunset to the mandatory obligation on generators to provide primary frequency response. In accordance with the sunset, the mandatory approach will be in place for a three-year period, expiring in June 2023.

The Commission's draft rule includes Schedule 2 which removes the mandatory primary frequency response framework from the rules as at 4 June 2023. The relevant rules will then revert to the version of those rules in existence at the time this rule is made.

This creates a clear signal that the Commission is committed to the development of an arrangement that appropriately incentivises primary frequency response provision to be put in place prior to the sunset. This also places a discipline on the market to focus on solutions that are sustainable in the longer-term.

Moving to a framework that incentivises primary frequency response

As part of the development of arrangements that incentivise primary frequency response, the Commission will be seeking to undertake an investigation into the power system requirements for maintaining good frequency performance. The Commission is aware that there is some analysis that indicates that effective frequency performance during normal

operation could be achieved with significantly less than the entire fleet being responsive to small frequency deviations during normal operation.

On 18 September 2019, AEMO published an updated report by DIGsilent which presented analysis and commentary on the further deterioration of frequency performance in the NEM since its earlier report in 2017. The DIGsilent report includes a summary of recent international developments in relation to frequency control and provides a number of recommendations to improve frequency control in the NEM. The updated DIGsilent report notes that international experience demonstrates that:[149]

> "A relatively small amount of primary frequency response can make a significant difference to the regulation of frequency"
>
> and
>
> "There is a cost to the market from requiring high efficiency plant to provide frequency control at the expense of energy"

However, the Commission also acknowledges the system operator's position and view that it is not appropriate to define a minimum level of responsive generation to meet the policy objectives in its mandatory primary frequency response rule change request. AEMO's submission notes that:[150]

> "A limited, or 'minimum level' provision of PFR from only a sub-set of capable generation focuses on improving a narrower distribution of frequency under normal operating conditions, but would not, by itself, achieve the other objectives. A widespread obligation:
>
> - diminishes the operational burden on any individual generator to the lowest practicable level and in an equitable as possible manner, thus reducing the longer term operating impacts for all generating systems;
> - ensures broad-based contribution to the public good of stable and resilient control of power system frequency; and
> - provides greater resilience and facilitates adequate control where a need for PFR arises, particularly where this need may initially be unforeseen.
>
> Compartmentalising the individual power system objectives and trying to manage them in isolation to a minimum level is unlikely to be successful."

Given these differing views, the Commission therefore considers that further work needs to be done to understand the power system requirements for maintaining good frequency control and the associated costs and benefits of alternative frequency control arrangements.

149 DIGsilent, Frequency in the Normal Operating Frequency Band - Update report for AEMO, 18 September 2019, p.31.
150 AEMO, Submission to the consultation paper, p.3-4.

This analysis should be undertaken through the assessment of AEMO's *Removal of disincentives to the provision of primary frequency response* rule change request.[151] This would consider further amendments to the NER in relation to the valuation and remuneration of frequency response and would include an assessment of what proportion of the fleet should provide PFR. It may be useful to think about this under the following conditions:

- *Following contingency events* — All capable generation plant should help support system security subject to plant safety limits and energy availability. From a system control perspective, it is not appropriate for latent generation capacity to exist in the power system at the same time as emergency frequency control schemes are operating to rebalance system supply and demand. The operation of emergency frequency control schemes is less predictable in a changing power system and successful operation can depend on the prevailing system conditions. Such emergency frequency control schemes include automatic under frequency load shedding or over-frequency generation shedding.
- *During normal operation* — It may be appropriate for a smaller proportion of the generation fleet to be actively involved in providing frequency response on a continuous basis. Such an approach allows for plant that is best suited to providing ongoing active power modulation to provide frequency control during normal operation, while other plant that is more suited to providing a steady power output can focus on the production of megawatts while being unresponsive to frequency variations within the NOFB.

The Commission considers that ideally an approach incorporating a mandatory contingency response requirement along with an incentive or marked-based provision of continuous primary regulating response would be implemented. However, given the immediate system security needs, and the advice from AEMO that the whole of the fleet should provide primary frequency response, the Commission proposes to undertake this work through AEMO's second rule change request. The development of an effective mechanism to value and reward provision of PFR is part of the future reform pathway set out in chapter 3.

Conditions of the mandatory obligation to be set out in the PFRR

The Commission's draft rule introduces a new clause 4.4.2(c1) of the NER to require that all registered scheduled and semi-scheduled generators, that have received a dispatch instruction for a volume greater than 0 MW, must operate their generating systems in accordance with the PFRR as applicable to that plant. AEMO may approve an exemption or variation to the requirement for specific generation plant which is technically incapable of complying with the requirements of the PFRR. This aspect of the draft rule is described further in Appendix C.

The Commission considers that AEMO's proposal of implementing the PFR requirement through Chapter 4 of the NER is more likely to achieve the desired result than implementation through Chapter 5 of the NER, as suggested by Dr. Sokolowski. Implementing the requirement through S5.2.5.11 would require provision of primary

151 This rule change request raises the issue of "poor frequency performance during normal operating conditions" and proposes changes to the NER to improve the incentives for generators providing PFR on a voluntary basis to assist in the control of frequency during normal operation.

frequency response from only new connecting generators, which would be unlikely to achieve the frequency performance objectives as put forward by AEMO which are aimed at capturing the entire fleet.

The Commission's draft rule will result in generators with a rated capacity less than 30 MW not being required to provide PFR unless they have registered as a scheduled or semi-scheduled generator.[152]

Under the draft rule, AEMO is responsible for developing and maintaining the PFRR in consultation with stakeholders, and for publishing the PFRR on its website.

AEMO submitted to the Commission an initial draft of the PFRR for consideration together with the rule change requests, and provided an updated version in October 2019. This can be found on our website.[153]AEMO will take into account stakeholder feedback provided through the rule change process in refining this, before finalising the document. The finalised document will form the initial interim PFRR, which will be adapted and refined over time. AEMO is required to develop and publish on its website the first PFRR under the new rules by 6 December 2021.

Following the formation of the interim PFRR (which will occur under this rule change process), any future changes to the PFRR post 6 December 2021 will be undertaken through the Rules consultation procedures. A further description of the interim PFRR, and the process for making changes to the initial PFRR in consultation with stakeholders, is set out in Appendix C.

Compliance testing and verification

The Commission notes the AER's concerns in relation to monitoring individual generator's compliance with the conditions of the PFRR. The Commission considers that initial testing and verification of compliance with the PFRR would be important. However, ongoing periodic assessment would likely be sufficient and that the installation of high-speed monitoring equipment in order to continuously assess compliance would likely be unnecessary.

In order to enable the initial and periodic assessment of compliance, the Commission has introduced a new clause 4.4.2A(4) under the draft rule to require that the PFRR include details of the information to be provided by generators to verify compliance with the PFRR and any compliance audits or tests to be conducted. This is consistent with AEMO's proposed rule.

Under the NER, providers of market ancillary services are required to install and maintain approved monitoring equipment to verify their compliance with the Market ancillary service specification (MASS).[154]

However, the Commission notes that not all generators provide market ancillary services, and so requiring all generators to install monitoring equipment to verify compliance with the PFRR

152 The Commission notes it has a pending rule change request from the Australian Energy Council that seeks to lower the threshold for generators to be scheduled to 30 MW.

153 The draft PFRR will need to be updated by AEMO to take into account the draft rule.

154 NER Clause 3.11.2(f)

would increase the overall costs associated with the draft rule. While AEMO did not propose such additional monitoring requirements in its rule change request, it did provide a commentary on how the expectations for generator performance under the proposed PFRR compare with that of FCAS providers under the MASS. [155]

> The PFRR does not specify a sustain time for the delivery of PFR. In this respect, the PFRR differs from the MASS, which requires that generating systems delivering PFR in the form of Contingency FCAS must be capable of delivering PFR consistent with its plant's FCAS market enablement, which will include an ability to sustain a response over a period appropriate for that Contingency FCAS
>
> [...]
>
> AEMO acknowledges that there are many reasons why plant might not be capable of sustaining its response, such as primary energy or environmental limits, or physical limits related to plant capability or safety, such as operating temperature limits, rough running zones, or pressure limits. A Generator would not be in breach of these requirements if it was unable to sustain PFR for such reasons.

AEMO explains that the intention of its proposed rule is for all capable generators to operate in a frequency response mode and for the generation control systems to be configured such that a generator's PFR is not counteracted by secondary control systems of plant load controllers.[156]

The Commission has made a draft rule that does not require the installation of any new or additional equipment for the purpose of verifying compliance with the mandatory PFR requirement, rather AEMO is required to document the audit and testing requirements for the purpose of verifying compliance through its PFRR.

Consistent with AEMO's proposed rule, the draft rule also introduces a new clause 4.4.2A(d) to require that AEMO publish on its website, and update as necessary, a register of generators who have been granted an exemption or variation from complying with some or all of the parameters set out in the PFRR. Further discussion of the exemption framework is set out in Appendix B.

No requirement to provide PFR unless dispatched in the energy or ancillary services markets

Clause 4.4.2(c1) of the draft rule states that each Scheduled Generator and Semi-Scheduled Generator that has received a dispatch instruction to generate at a volume greater than 0 MW must operate its generating system in accordance with the Primary Frequency Response Requirements as applicable to that generating system.

The Commission acknowledges concerns raised by providers of battery energy storage systems that batteries would likely be disproportionately burdened by a mandatory approach since they are always available to the market, even when not enabled for energy or FCAS. Clause 4.4.2(c1) of the draft rule requires that generators only operate their generating

155 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, pp.52-53.
156 Ibid.

systems in accordance with the PFRR when they have received a dispatch instruction to generate at a volume greater than 0 MW.

Specification in the NER that generators are not required to maintain headroom

As set out in section A.3, a number of stakeholders are concerned that any proposal to mandate the provision of additional headroom (stored energy for frequency control) could lead to substantial ongoing costs for generators.

The Commission acknowledges that AEMO's rule change request did not include a requirement that generators maintain headroom, and that the draft PFRR specifically states that the provision of additional headroom is not required in order to comply. The Commission considers it appropriate that AEMO has the power to adjust the PFRR from time to time in order to manage the technical performance criteria and settings for generation plant that are connected to the national electricity system and are registered to participate in the NEM. However, the Commission notes that, in the context of addressing the immediate concerns with power system frequency control, this power need not extend to decisions around the requirement for generators to maintain additional stored energy for frequency control.

Indeed, any future obligation that results in a large cross-section of the generating fleet maintaining stored energy would likely impose substantial costs on generators that outweigh the additional benefits this might provide to the security of the power system. Therefore, the draft rule provides that the PFRR cannot require generators to maintain additional stored energy as a condition of complying with the requirements of the PFRR. This aspect of the draft rule provides greater clarity and certainty to generators and will limit the likelihood of substantial unwarranted costs being incurred by generators in the future.

A.4.2 Governance arrangements

Specification of the maximum allowable deadband in the NER

The frequency operating standard (FOS) is set by the Reliability Panel. It sets out the operational requirements for power system frequency in the NEM by defining the allowable power system frequency range for a certain set of power system conditions.

Under the current arrangements, AEMO operates the power system, including through the dispatch of electricity and market ancillary services in accordance with the FOS during normal operation and following contingency events.

The FOS therefore provides transparent and definitive guidance to AEMO to operate the power system to a standard that benefits market participants and provides a reliable supply of electricity to consumers.

The intent of AEMO's *Mandatory primary frequency response* rule change request is not to revise the FOS itself, but instead to change the operating requirements for generating plant in the NEM as the means of achieving improved frequency performance. AEMO's rule change request suggested that the desired frequency performance ought to be defined through the obligations placed on market participants through the primary frequency response requirements (PFRR). The generator frequency response deadbands proposed in AEMO's

proposed rule, and in Dr. Sokolowski proposed rule, therefore operate as a quasi-system standard. The Commission expects that following full implementation of the PFRR, this improved frequency performance would effectively mean that the current requirements of the FOS would be exceeded.

The Commission considers that in general it is appropriate for AEMO to manage the technical performance criteria and settings for generation plant that are connected to the national electricity system and that are registered to participate in the NEM. However, the Commission considers that the maximum allowable frequency response dead band is a key variable associated with the proposed rule. This setting has implications not only for the secure and stable operation of the power system but also for the economic operation of the NEM.

Where a particular setting has broader economic or market impacts it may be more appropriate for that setting to be determined by the AEMC or the Reliability Panel to make economic trade-offs with consideration of the national electricity objective. However, given the need for an immediate policy change to restore effective frequency control in the NEM, the Commission agrees with AEMO's position that it is not appropriate to consider revising the FOS and determining a new market or performance-based mechanism at this time. Such a policy approach would lead to a delayed implementation of a solution to the immediate power system frequency issues.

On account of the importance and broader implications of this setting, the Commission has determined that the draft rule authorise AEMO to specify a maximum allowable frequency response dead band in the PFRR, but that the NER specifies a lower bound for the maximum allowable frequency response band (the *primary frequency control band*). In the absence of a clearly defined frequency performance standard in the FOS, the Commission has determined that the minimum bound for the maximum allowable deadband be specified in the NER, and not subject to full discretion by AEMO in the PFRR. This is consistent with the pre-NEM arrangements in the National Electricity Code that included the specification of the maximum allowable deadband for generating units, rather this being in subsidiary documents or standards.

The frequency regulating band is also a key variable in the implementation of the AEMC's future reform pathway and it is therefore appropriate that the band be specified in the NER to allow the AEMC to review and revise this setting at a future date.

The draft rule introduces a new term in Chapter 10 of the NER — the *primary frequency control band* — outside of which AEMO may set the mandatory primary frequency response deadband that applies to generators. The *primary frequency control band* will be set at the range of 49.985Hz to 50.015Hz (±0.015Hz) (or such other range as specified by the Reliability Panel in the power system security standards) and will be expressed as a minimum bound, meaning that an individual generator may provide a frequency response at a deadband wider than this range if agreed with AEMO but will not be required to provide a frequency response to a deadband that is within this range. This frequency range is consistent with AEMO's rule change request.

The specification of the *primary frequency control band* in the NER or by the Reliability Panel is not intended to create the impression that generators must operate their plant to that

band or that a narrower response band is not allowed under the NER. Generators would be able to operate their plant on a narrower deadband if they chose to.

The Commission recognises that narrow band primary frequency response from all capable generation plant is likely to achieve the operational objectives identified by AEMO in its rule change request, namely:[157]

- Re-establish effective control of power system frequency, and thereby align the NEM with standard international practice.
- Increase the resilience of the power system to disturbances, particularly events beyond simple credible contingency events.
- Ensure a predictable frequency response from generation to power system disturbances, to support power system planning and modelling.

However, the Commission also recognises that a mandatory requirement for narrow band PFR may not be the only viable solution that achieves the identified objectives. Other potential solutions may include a mandatory frequency response backstop as a wider frequency band complemented by the introduction of new incentive or market arrangements to provides sufficient narrow band PFR on a continuous basis to help control frequency during normal operating conditions. Consideration of such alternative options aligns with stakeholder views that it may be more appropriate for a mandatory primary frequency response band to be set at a wider range than the ±0.015Hz proposed by AEMO.

The Commission considers that the introduction of an interim arrangement for mandatory narrow band PFR will allow time for further consideration of how power system frequency performance is specified in the Frequency operating standard and the design of appropriate tools to enable AEMO to effectively manage the power system in accordance with the Frequency operating standard. This review will be considered as part of the future reform pathway described in chapter 3 of this draft determination.

Interactions with the generator performance standards for frequency control

The Commission notes AEMO's proposal in its rule change request that the generator performance standards under S5.2.5.11 in the NER be amended to remove any potential ambiguity with respect to the PFRR. AEMO proposed that compliance with the automatic and minimum access standards would be 'subject to the *primary frequency response requirements*. The Commission has considered AEMO's proposal and has determined not to include this proposed change as part of the draft rule.

The Commission considers that the minimum and automatic generator access standards set out under clause S5.2.5.11 of the NER should take priority over any potential obligations set out in the PFRR. Any changes to the capability requirements for new connecting generation should be undertaken through the rule change process. By including AEMO's proposed wording as part of S5.2.5.11, the access standards would in effect be subordinate to any future changes to the PFRR.

157 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, p.28.

The Commission considers that the conditions set out in the PFRR should be specified so as not to conflict with the generators access standards as set out in the NER. Indeed, the Commission acknowledges AEMO's statement in its submission on the consultation paper that the capabilities required under the draft PFRR are not more onerous than the access standards on clause S5.2.5.11, or in other existing minimum access standards in clause S5.2.5.

In addition, given that the draft rule places a primary frequency response requirement on all scheduled and semi-scheduled generation, which would meet AEMO's system security needs, then any changes to the generator performance standards are unnecessary and duplicative.

BOX 4: EXISTING REQUIREMENTS FOR FREQUENCY CONTROL CAPABILITY

Clause S5.2.5.11 of the NER includes minimum and automatic technical requirements for a generating system in relation to frequency control.

The general requirements for generator frequency control include that the generating system must be capable of:[1]

- setting a frequency response deadband within the range of 0 to ± 1.0 Hz
- setting a droop within the range of 2% to 10%.

The minimum access standard for generator frequency control requires that:[2]

- in response to a rise in system frequency, a generator's output must not worsen an over frequency situation
- in response to a fall in system frequency, a generator's output must not decrease more than 2% per Hz
- the generating system must be capable of operating in a frequency response mode such that, subject to energy source availability, it responds to a rise in frequency by decreasing power output and responds to a decrease in frequency by increasing power output.

The automatic access standard for generator frequency control states that the generating system has the capability to operate in a frequency responsive mode such that it responds to a rise in frequency by proportionally decreasing power output and responds to a decrease in frequency by proportionally increasing power output.[3]

All generators connected on or after 5 October 2018 have a negotiated access agreement at or between these two standards.

Source: National electricity rules, version 129.
Note: 1. NER Clause S.5.2.5.11(i)(2)
Note: 2. NER Clause S.5.2.5.11(c)
Note: 3. NER Clause S.5.2.5.11(b)

B EXEMPTIONS FROM THE PFR REQUIREMENT

The draft rule includes an exemption framework that enables Generators to apply to AEMO for an exemption or variation from the technical obligations set out in AEMO's *Primary frequency response requirements (PFRR)*. The draft rule also includes a list of principles that AEMO must have regard to when approving exemptions and variations from the *Primary frequency response requirements*.

This appendix describes the Commission's considerations in relation to the exemption framework that is included in the draft rule.

B.1 Proponents views

B.1.1 AEMO's proposal

AEMO has indicated that it expects many generators would not need to make substantive changes to their plant control systems to meet the requirements of the proposed rule, other than perhaps reducing the deadbands outside which frequency response was delivered, or selecting their plant load controllers to operate in a manner that supports frequency response.[158] AEMO's intent is that such plant would be required to comply with the primary frequency response performance requirements set out in the PFRR.

In its rule change request, AEMO recognised that there were likely to be some generating plant for which it is uneconomic to apply the mandatory PFR requirement. AEMO's intention is that generation plant that is not technically capable of providing PFR in accordance with the PFRR be eligible for exemption or variation to the PFR requirement.[159]

AEMO's proposed rule included provision for AEMO to approve a variation or exemption for a generator in respect of any performance parameter for PFR. Under its proposed rule, AEMO would set out the conditions for granting such a variation or exemption in its PFRR.[160]

AEMO's preliminary PFRR includes the following guidance in relation to the process and criteria for AEMO providing exemptions to the proposed PFR requirement:[161]

- A full exemption may be provided where plant is inherently incapable of making control system changes to be compliant with the PFRR, or that significant plant augmentation would be required to be compliant.
- A partial exemption or variation to the requirement may be provided if AEMO determines that full compliance with the technical requirements would adversely impact system security.

AEMO's preliminary PFRR also includes provision for standing exemptions to be in place for:

- The steam turbine component of a combined cycle gas generator.
- A generating system operating in synchronous condenser mode.

158 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, p.29.
159 Ibid.
160 AEMO, Mandatory primary frequency response — proposed rule, 16 August 2019, cl 4.4.2A(a)(iii).
161 AEMO, Draft Primary frequency response requirements, 17 October 2019, p.9.

In addition, AEMO's proposed rule applies the mandatory primary frequency response requirement to all market participants registered as scheduled and semi-scheduled generators. AEMO's proposed rule would not apply to participants in the NEM that are registered as non-scheduled generators.[162] This effectively exempts generators with a nameplate rating less than 30MW that export less than 20GWh in any 12-month period, as such generators are not required to register as scheduled and semi-scheduled generators.[163]

AEMO proposes to publish and maintain a list of generating plant containing the details of their PFRR exemption or compliance status.

B.1.2 Dr. Sokolowski's proposal

Dr Sokolowksi's rule change request, Primary frequency response requirements, did not include any provision for exemption or variation of the requirement to provide primary frequency response.

B.2 Stakeholders views

A number of stakeholders expressed support for the inclusion of an exemption process as part of AEMO's proposed rule, *Mandatory primary frequency response*.[164]

Some stakeholders requested further detail and transparency in relation to how the exemption process proposed by AEMO would work in practice.[165]

Alinta Energy raised concerns that if a substantial portion of the generation fleet were exempted from the proposed mandatory requirement, the cost of providing frequency response in accordance with the requirement may be significantly increased for the remaining responsive portion of the fleet. As such Alinta Energy urged that:[166]

> any exemption criteria must be drafted precisely to ensure appropriate definitions exist which methodically outline a stringent criterion to whom exemptions can apply and under what specific grounds...

While the CEC supported the inclusion of an exemption process as part of a mandatory PFR requirement, it also noted that:[167]

> Further details are needed from AEMO on what would constitute 'significant augmentation' so generators can appropriately assess if they would be exempt. We also suggest the AEMC consider the inclusion of these exemption provisions within the NER.

IES proposed an alternative approach

---

162 Refer to NER rule 2.2.3

163 AEMO, Guide to NEM generator classification and exemption, August 2014, p.14.

164 Submissions to the consultation paper: Alinta Energy, p.4.; CEC, p.4.; Hydro Tasmania, p.2.; Meridian Energy, p.5.; Tilt Renewables, p.2.;

165 Submissions to the Consultation paper: CEC, p.4.; Energy Australia, p.7.; Stanwell p.6.;

166 Alinta Energy, Submission to the Consultation paper, pp.4-5.

167 CEC, Submission to the Consultation paper, p.4

IES suggested an alternative exemption approach, where a standing exemption would apply to generators with a nameplate capacity less than 200MW. IES reasoned that these large generating plant typically already have the capability to provide narrow band PFR and that this capability can be activated at relatively low cost. Furthermore, IES reasoned that it is likely to be more costly and problematic for smaller generating plant to comply with the PFRR due in part to the increased proportion of variable renewable generation and battery energy storage systems.[168]

B.3 Commission's analysis

BOX 5: SUMMARY OF DRAFT RULE

The draft rule includes an exemption framework that is based on the approach set out in AEMO's proposed rule. The draft rule introduces a new clause 4.4.2A(b)(2) which requires that the PFRR include the conditions or criteria for Generators to request, and AEMO to approve, an exemption or variation from the requirements specified by AEMO in the *Primary frequency response requirements*. The Commission agrees that AEMO is the appropriate party to administer the exemption process since they are the system operator and so have the technical information required to assess both costs, as well as the effect that the exemption would have on frequency performance.

The draft rule introduces a new clause 4.4.2B which sets out the following criteria which AEMO must have regard to in considering such a request:

(1) the capability of the generating system to operate in frequency response mode;

(2) the costs that are likely to be incurred in augmenting the generating system to be able to operate in frequency response mode, relative to the turnover derived from, and operating hours of, the generating system in relation to its operation in the *national electricity market*;

(3) the stability of the generating system when operating in frequency response mode, and the potential impact this may have on power system security;

(4) the ongoing costs of operating the generating system in frequency response mode; and

(5) any other physical characteristics of the generating system which may affect its ability to operate in frequency response mode, including (but not limited

168 IES, Submission to the Consultation paper, p.4.

to) dispatch inflexibility profile, operating requirements, or energy constraints.

As described in Appendix B, the objective for the draft rule is that all technically capable scheduled and semi-scheduled generation comply with the proposed PFR requirement.

The Commission expects that the costs for each generator to meet the technical requirements for PFR will vary. Some generation plant are likely to meet the technical requirements for PFR with minimal need for plant changes. The capability from these generators can be utilised for a relatively low upfront implementation cost. Other generation plant will require more significant plant upgrades and control system tuning in order to provide PFR in accordance with the technical requirements.

In the absence of an exemption framework some generators may be forced to incur substantial costs for plant upgrades to comply with the PFR requirement. An effective exemption framework can introduce a degree of flexibility that avoids excessive compliance costs for eligible generation plant while still delivering on the system security and frequency control objectives. The exemption framework in the draft rule provides for this flexibility while at the same time setting out a series of principles to improve the transparency of the exemption process, while also still meeting the immediate system security needs.

Objective of an exemption framework

The Commission considers that an effective and transparent exemption framework can add a degree of flexibility to a mandatory primary frequency control requirement. While it is expected that some proportion of the generation fleet would meet the technical requirements for primary frequency response without the need for expensive plant upgrades, this will not be the case for the entire generation fleet. Some generating plant are not inherently able to comply with the proposed primary frequency response requirements, and it is expected that these plant would incur significant costs if they were required to do so. Therefore, the Commission recognises the importance of including a provision for generators to obtain exemptions or variations to AEMO's proposed PFRR where it can be demonstrated that the costs of compliance would be likely to be excessive.

The objective of such an exemption framework is to avoid excessive costs and risks associated with the application of a mandatory primary frequency response requirement to all scheduled and semi-scheduled generators in the NEM. At the same time, the exemption framework should not be so lenient as to undermine the broad based nature of the proposed mandatory PFR arrangement. As discussed in appendix A, AEMO's and Dr John Undrill's advice is that the entire fleet should provide primary frequency response, and indeed, to do this, potentially could be cheaper than just a subset of the fleet. Therefore, it is important that the exemption framework does not unnecessarily exempt parties.

Consideration of stakeholder comments

The Commission notes stakeholder concerns in relation to how AEMO's proposed exemption process would work in practice. The Commission understands that stakeholders would appreciate that a rule for mandatory primary frequency response include additional detail to guide AEMO's management of the exemption process. The more preferable draft rule includes a list of principles that AEMO must have regard to in developing its process to assess and approve any request for exemption or variation to the *Primary frequency response requirements.*

In relation to the IES proposal that a mandatory PFR requirement be applied to generation with a nameplate capacity over 200MW, the Commission note that this approach would exempt approximately 20GW (38 per cent), of the existing 53GW of registered generation in the NEM.[169] It is understood that defining a sub-set of the generation fleet in this way does not align with AEMO's objectives for power system frequency control as set out in its rule change request, which was to maximise the proportion of the fleet providing primary frequency response. AEMO considers that the operational objectives are best served through the application of the mandatory primary frequency response requirement to all capable scheduled and semi-scheduled generators in the NEM.[170]

Commission's analysis

The Commission agrees with AEMO and stakeholders that an exemption process is likely to improve the flexibility and transparency of a mandatory PFR rule. In developing the draft rule, the Commission considered how prescriptive the rule should be in relation to an exemption process. The Commission recognises that the degree to which the exemption process is set out in the rules impacts on the transparency, workability and flexibility of the rule. The Commission considers that a principles-based approach is in the best interests of AEMO and market participants.

There are a number of ways in which the Commission could introduce a greater degree of prescription into the exemption framework. Exemptions could be determined by generating technologies, tasks, or a simple cost threshold. Greater prescription would provide market participants with the increased transparency and certainty as to how the rule impacts their operations. However, a prescriptive approach would also reduce the flexibility of the mandatory PFR rule which may result in excessive costs, if too few generators are exempt, or diminish AEMO's ability to manage the security of the power system, if too many generators are exempt.

In the context of applying a mandatory requirement for generators to be frequency responsive, as noted above, the Commission considers that AEMO is best placed to make decisions as to which plant should be granted exemptions or variations from the PFRR. However, the Commission agrees with the submissions from the CEC, Energy Australia and Stanwell that it is appropriate for the rule to provide AEMO with additional guidance in relation to the exemption process. As set out above, the draft rule includes a set of five criteria that AEMO must consider in assessing an exemption or variation from the PFRR.

169 AEMO, Generation information, 14 November 2019

170 AEMO, Submission to the Consultation paper, p.4.

The Commission is interested to hear from stakeholders on the appropriateness of the exemption criteria set out in the draft rule in the context of improving the practicality, flexibility and transparency of the exemption framework.

C IMPLEMENTATION AND TRANSITIONAL ARRANGEMENTS

This appendix sets out the steps and timetable for implementing the rule, including the steps that will need to be taken by AEMO to develop and implement the interim *Primary frequency response requirements (PFRR)*.

If the Commission makes a final rule that is consistent with the draft rule, the substantive parts of the rule implementing the mandatory primary frequency response requirement will commence on 4 June 2020.

This chapter also sets out the transitional clauses that would commence on the date the rule is made.

C.1 Proponents' views

C.1.1 AEMO's views

AEMO's proposed rule includes a framework for implementation of the mandatory primary frequency response requirement that is set out in proposed transitional rules.[171] The key elements of AEMO's implementation process for its proposed rule include that:

- AEMO is to develop and publish an interim *Primary frequency response requirements* to apply from the commencement date of the rule.
- The interim *Primary frequency response requirements* specify the date by which generators must comply with the obligation, which may vary by plant type.
- Generators may submit a claim to AEMO for reimbursement of costs associated with plant upgrades to become compliant with the *Primary frequency response requirements*.
- In relation to costs incurred by AEMO for reimbursing generators for approved plant upgrade costs, AEMO may recover these costs through participant fees.

Implementation plan in AEMO's draft *Primary frequency response requirements*

In addition to the proposed transitional arrangements for implementation of its proposed rule, AEMO provided to the Commission a draft *Primary frequency response requirements* which provides an indication of its proposed process and time frame for activation of changes to generator control systems. The process and time frames set out in AEMO's draft *Primary frequency response requirements* include:[172]

- Scheduled and semi-scheduled generating systems with a nameplate rating of 200 MW or more must complete a self-assessment of the ability of their generating system to meet the technical requirements and submit this to AEMO within 60 business days of the commencement date for the *Primary frequency response requirements.*

171 Ibid.

172 AEMO, Primary frequency response requirements - draft version 1.1, 17 October 2019, p.8.

- Scheduled and semi-scheduled generating systems with a nameplate rating less than 200 MW must complete a self-assessment of the ability of their generating system to meet the technical requirements and submit this to AEMO within 120 business days of the commencement date for the *Primary frequency response requirements.*
- AEMO will respond to each generator within 20 business days of receiving its self-assessment.

The preliminary draft *Primary frequency response requirements* does not include a date by which generators must comply with the obligation, as proposed under AEMO's proposed transitional rules. The Commission understands that AEMO would need to set out this detail at a later date, prior to the commencement of the interim *Primary frequency response requirements.*

AEMO's understanding of the scale of expected plant upgrade costs

AEMO has indicated that it expects the cost of changes to generators' plant control systems to comply with the technical requirements for primary frequency response to be relatively minor for most generating systems.[173] AEMO's submission to the consultation paper explained that its specification of the technical requirements for primary frequency response was conceived on the basis that the most onerous change that most generators might have to undertake would be a change in control system settings. Its submission noted that:[174]

> AEMO are aware that some generating systems can make control system changes to become compliant with the PFRR at near zero cost, and at very short notice. AEMO are also aware that more significant, time consuming, complex and costly changes may be required for other generating systems.

AEMO indicated that it may grant a full or partial exemption from the technical requirements for primary frequency response where the upfront costs for plant upgrades are unreasonable and the exemption would not adversely impact on power system security.[175]

C.1.2 Dr. Sokolowski's views

Dr Sokolowski did not include any commentary on implementation and transitional arrangements in his proposed rule change request or rule drafting.

C.2 Stakeholder views

This section summarises the views of stakeholders in relation to the implementation of a mandatory primary frequency response requirement based on submissions received in response to the consultation paper, *Primary frequency response rule changes*.

173 Ibid. p.55.
174 AEMO, Submission to the consultation paper, 31 October 2019, p.8.
175 Ibid.

C.2.1 Implementation process

A number of generators expressed concerns in relation to the implementation process and time frames set out in AEMO's proposed rule and its draft *Primary frequency response requirements.* Generators were concerned that the hasty or uncoordinated implementation of changes to generator control systems may pose risks to generation plant and power system security including:

- risk of generators interacting with each other to cause hunting and oscillations in power system frequency.[176]
- risk of early movers bearing a disproportionate increase in operating costs. [177]
- risk of unintended consequences due to the proposed deadband of ±0.015Hz being untested in the history of the NEM. [178] For example, Alinta Energy consider that the implementation of the proposed mandatory PFR requirement may undermine the operation of thermal generators during low load conditions or fast ramping conditions.[179]

Meridian Energy expressed support for the proposed 120 business-day period for self assessment of generators under 200MW, while also noting that the justification for the 60 business-day self-assessment time frame for larger generators is not clear.[180]

Alinta Energy also expressed concern that the AEMO's proposed time-frame of 60 business days for self-assessment of large generators >200MW is unreasonably short and that an expedited approach to implementation of plant changes may drive scarcity pricing for the specialised engineering services required to advise on changes to generation control systems. Alinta Energy suggested that:[181]

> A progressively implemented and ordered reduction in dead band settings over a period of 12-18 months (at a minimum) in order to progressively monitor the performance of frequency of the NEM appears a more appropriate solution.

EnergyAustralia noted that:[182]

> AEMO's Primary Frequency Response Requirements (PFRR) document provides no details around how AEMO would manage implementation

Infigen suggested that, while a more comprehensive market solution is being developed, the implementation of the mandatory PFR requirement could follow an extended staged approach based on the implementation tranches set out by AEMO in its rule change request. Under its proposed approach, Infigen suggested that AEMO could:[183]

176 Submissions to the consultation paper: ERM Power, p.9; Stanwell, p.5.
177 Submissions to the consultation paper: EnergyAustralia, p.6; Stanwell, p.6.
178 Submissions to the consultation paper: Alinta Energy, p.3; ERM Power, p.9; Delta Electricity, p.1.
179 Alinta Energy, Submission to the Consultation paper, p.3.
180 MEA Group, Submission to the consultation paper, p.3.
181 Alinta Energy, Submission to the consultation paper, p.5.
182 EnergyAustralia, Submission to the consultation paper, p.7.
183 Infigen, Submission to the consultation paper, pp.7-8.

- Initially, seek a mandatory response from large synchronous units (200 MW+) and observe the resulting frequency performance (6-12 months);
- If insufficient, then seek response from smaller synchronous units;
- Finally, if performance is still unsatisfactory, and a market mechanism has not been developed, seek response from non-synchronous units, where [the] cost of provision is likely to be highest.

C.2.2 Recovery of upfront costs

A number of generators were supportive of AEMO's proposed process to reimburse generators for costs associated with plant changes to provide PFR in accordance with the proposed *Primary frequency response requirements*.[184]

Origin Energy noted that any consideration of upfront costs should include costs associated with updating generator models.[185]

Energy Australia noted that consideration of upfront costs should take into account costs associated with outages for generation plant to make the required changes.[186]

C.3 Commission's analysis and conclusions

BOX 6: SUMMARY OF DRAFT RULE

The draft rule requires AEMO to develop interim *Primary frequency response requirements* to be in place prior to the commencement date of the rule on 4 June 2020. AEMO has confirmed that it is comfortable with this commencement date.

In addition to the technical criteria for the provision of PFR, the interim *Primary frequency response requirements* would also document AEMO's process for coordinating changes to generation plant associated with activation of the frequency response mode as intended by the *Mandatory primary frequency response* rule. This process would include the date by which each generator must comply with the performance requirements set out in the *Primary frequency response requirements*.

AEMO's proposed rule included transitional arrangements for Generators to submit a claim for reimbursement of costs associated with plant upgrades to become compliant with the *Primary frequency response requirements*, and for AEMO to recover its associated costs through participant fees. The Commission does not consider that it would be necessary or appropriate to reimburse market participants for costs associated with complying with the proposed PFR requirement. Therefore, the draft rule:

184 Submission to the consultation paper: Alinta Energy, p.4; Delta Electricity, p.16; MEA Group, p.4.
185 Origin Energy, Submission to the consultation paper, p.4.
186 Energy Australia, Submission to the consultation paper, p.7.

- does not include any transitional arrangements for affected generators to be directly reimbursed for plant upgrade costs;
- does not include any transitional arrangements for AEMO to recover such associated costs through market participants fees.

C.3.1 Implementation

This section describes the transitional rules included in the draft rule. The transitional rules set out:

- The process for AEMO to develop and publish the interim *Primary frequency response requirements* to apply from the commencement date of the rule.
- The content of the interim *Primary frequency response requirements,* including documentation of the process for the coordinated activation of changes to generation plant.

Development of the interim *Primary frequency response requirements*

Consistent with AEMO's proposed rule, the draft rule includes transitional arrangements that require AEMO to prepare interim *Primary Frequency Response Requirements* to apply from 4 June 2020. As proposed by AEMO, the interim *Primary Frequency Response requirements* will set out:

- The information required under new clause 4.4.2A(b) including:
  - the technical requirements for Primary frequency response
  - the process for generators to request a full or partial exemption from the *Primary Frequency Response requirements.*
- The date, which may vary by plant type, by which Scheduled Generators and Semi-Scheduled Generators must effect changes to their plant to comply with the Interim *Primary frequency response requirements*.

The Commission acknowledges stakeholder concerns in relation to the coordination of plant changes associated with the implementation of the mandatory primary frequency response requirement. To address these concerns the more preferable draft rule also requires that:

- AEMO consult with stakeholders on the development of the interim *Primary frequency response requirements* - AEMO to publish a draft *Interim Primary frequency response requirements* by 9 April 2020 and invite stakeholder submissions on this draft for a period of 20 business days.
- The interim *Primary frequency response requirements* document AEMO's process for the coordinated activation of changes to generation plant.

The time-frames set out in the draft rule for the development of the interim *Primary frequency response requirements* are summarised in Table C.1. The Commission understands from AEMO that the commencement date of 4 June 2020 will not delay the overall implementation of the mandatory PFR requirement. This date represents the latest date that

AEMO may publish the interim *Primary frequency response requirements*. The draft rule authorises AEMO to commence its consultation earlier and be able to publish the interim *Primary frequency response requirements* earlier at its discretion. Given the immediate need for improved frequency control identified by AEMO in its rule change request, the Commission encourages AEMO to investigate options to bring forward the generator self assessment process to expedite the time frame for activation of change to generator control systems to provide PFR in accordance with the interim *Primary frequency response requirements*.

Table C.1: Time-frames under the draft rule for development of the interim *Primary frequency response requirements*

DATE	ACTION
26 March 2020	The AEMC publishes the final determination and final rule, *Mandatory primary frequency response* Commencement date for the transitional rules set out in schedule 3 of the Amending Rule.
9 April 2020	AEMO publishes a draft *Interim primary frequency response requirements*
(+ 20 business days) 7 May 2020	Close of submissions on the draft *Interim primary frequency response requirements*
4 June 2020	AEMO publishes the *Interim primary frequency response requirements* Commencement date for the substantive elements of the rule, *Mandatory primary frequency response,* as set out in schedule 1 of the Amending Rule.

C.3.2 Cost recovery arrangements for upfront costs

Existing generators required to comply with the *Primary frequency response requirements* would likely incur one-off upfront costs, as acknowledged in Appendix A. These costs are likely to be different for each generator. As noted by AEMO, some generation plant are likely to meet the technical requirements for primary frequency response with minimal need for plant changes, and at relatively low upfront cost. Other generation plant would require more significant plant upgrades and control system tuning in order to provide primary frequency response in accordance with the technical requirements.

The Commission does not consider that the draft rule places any additional obligations on connecting Generators, over and above the existing requirements for frequency control capability set out in Clause S5.2.5.11.[187] Therefore, the consideration of cost recovery for upfront costs is limited to the impacts on and arrangements for existing Generators.

The Commission has considered two alternative approaches by which existing generators may recover these upfront costs:

1. Direct reimbursement of approved costs from AEMO to affected participants similar to the arrangement in AEMO's proposed rule
2. No direct reimbursement — generators would recover their costs through their participation in the energy and ancillary service markets.

The Commission's investigation of reasons for and against the direct reimbursement of plant upgrade costs is set out below.

Reasons not to provide direct reimbursement of plant upgrade costs

In considering whether to make a draft rule that includes the direct reimbursement and cost recovery arrangements included in AEMO proposed rule, the Commission notes that compensation is not typically provided to affected parties for the costs associated with complying with an amendment to the NER. The following reasons support the determination of a draft rule that does not provide for direct reimbursement of plant upgrades costs:

- The inclusion of an arrangement for direct reimbursement of plant upgrade costs provides little incentive for affected generators to minimise the costs of plant upgrades. This exposes consumers to the risk that the total cost of plant upgrades exceeds the minimum necessary cost to deliver the required level of frequency improvement.
- In most cases, generator upgrades will contribute to the development of a capability that may be utilised by affected generators to obtain a revenue stream for frequency response through the present and future market arrangements for FCAS.
- The costs for plant upgrades and control system changes are expected to be relatively minor and manageable for most affected generators. Where the costs of plant upgrades are more substantial, it is intended that a generator will be eligible for a full or partial exemption from the requirement to avoid or reduce the upfront cost. The draft rule includes a framework for generators to request an exemption from all or part of the *Primary frequency response requirements*. This exemption framework is described in Appendix B.

Potential reasons to provide direct reimbursement of plant upgrade costs

The Commission has considered whether there are any reasons for the draft rule to provide for existing generators to be directly reimbursed for approved plant upgrade costs to comply with the primary frequency response requirement.

187 Since 5 October 2018, connecting Generators are required to have the capability to operate in a frequency response mode and be capable of setting a droop within the range 2% - 10% and a deadband within the range 0 to ± 1.0Hz. NER Clause S.5.2.5.11(c)(2) and NER Clause S5.2.5.11(i)(2).

The following scenarios may support the inclusion of a provision for direct reimbursement of generator upgrade costs as part of a draft rule for mandatory primary frequency response:

- if transitional assistance were required for plant upgrades to be undertaken in an expedited time frame
- if the costs of complying with the rule were such that failure to provide direct reimbursement of costs would undermine the commercial viability of participants in the NEM or constitute a significant risk to future investment

Each of these scenarios is discussed below.

Consideration of the time frame for compliance with the draft rule

The Commission has considered whether there is any justification for paying compensation to existing generators on the basis that they may incur higher upfront costs than would normally be expected due to an expedited requirement to implement plant changes to comply with the draft rule.

The Commission considers that the proposed time frame for implementation of the draft rule and subsequent implementation of plant changes is reasonable, noting AEMO's understanding that for many generators the expected plant changes are relatively minor and can be undertaken at short notice.[188]

AEMO's proposed implementation plan includes a staged approach under which technically capable generators with a nameplate rating over 200 MW would be expected to implement plant changes first. The remaining technically capable generating systems would be expected to implement plant changes at a later date.[189]

Where changes to generation plant to comply with the primary frequency response requirement are more complex, costly or time-consuming, the draft rule provides for an exemption process which requires AEMO to consider, among other things, the costs associated with plant augmentation to comply with the *Primary frequency response requirements.* The exemption framework is described in Appendix B.

In the context of the proposed exemption process and the staged implementation of plant changes, the Commission does not consider that direct compensation is justified on account of any expedited implementation of the mandatory primary frequency response requirement.

Consideration of impacts on investor confidence and the commercial viability of generation

The direct reimbursement of some or all costs associated with compliance with a regulatory change may be justified where the costs associated with the new regulatory obligation are substantial, and affected participants are not able to effectively recover these costs through participation in the energy market. Under such a scenario, applying the new regulatory obligation in the absence of some level of compensation may constitute a material risk to the commercial viability of participants in the NEM or significantly undermine investor confidence.

188 AEMO, Submission to the consultation paper, 31 October 2019, p.8.

189 AEMO, Mandatory Primary frequency response — Electricity rule change proposal, 16 August 2019, p.44.

The Commission has considered the scale of the expected costs associated with plant upgrades to comply with the primary frequency response requirement and whether it is reasonable to expect market participants to recover these costs through their participation in the energy market. The Commission notes that the draft rule and current version of the *Primary frequency response requirements* include an exemption process that is intended to reduce or avoid excessive upfront costs for generators where plant upgrades may be more complex or costly.

The Commission has worked with AEMO to estimate the scale of the likely costs associated with required plant changes to comply with the technical requirements set out in the *Primary frequency response requirements.* The Commission's estimate of the total one-off upfront cost for the eligible generators to implement the required changes to their generating systems may be in the order of tens of millions of dollars across the entire generation fleet in the NEM. The Commission considers that the scale of these expected costs is relatively minor when compared with the $220 million annual cost of regulation FCAS in 2018 and the total annual value of energy turnover in the NEM in 2018/19 financial year of $18.3 billion.[190]

The Commission expects that the costs associated with plant upgrades to comply with the draft rule are therefore not likely to constitute a substantive commercial risk to market participants, nor are they likely to significantly undermine investor confidence in future generation. Therefore, the Commission does not consider that direct compensation for upfront costs associated with compliance with the draft rule is justified to make up for any associated commercial or investment risk.

Conclusion

The Commission considers that the inclusion of arrangements to compensate scheduled and semi-scheduled generators for the costs of complying with the draft rule cannot be justified on any commercial, legal or economic grounds. Therefore, the Commission has made a more preferable draft rule that does not provide for existing generators to claim for and receive compensation for approved plant upgrade costs. As a consequence, the more preferable draft rule also does not include any arrangements for AEMO to recover its costs associated with reimbursing existing generators for approved plant upgrade costs.

190 AEMO, Quarterly energy dynamics - Q3 2019 workbook, 12 November 2019, Figure 27 - Quarterly FCAS costs by service. AEMO, AEMO Annual Report 2019, 15 October 2019, p.21.

D OTHER PROPOSED CHANGES

This appendix describes the Commission's considerations with respect to a number of other changes to the NER proposed by AEMO and Dr. Sokolowski in their rule change requests.

This appendix sets out stakeholders' views and the Commission's conclusions on these proposed changes.

- Section D.1. covers other proposed changes that relate to the provision of PFR, including to the arrangements in the NER that relate to:
  - contribution factors for allocation of the costs of regulation services
  - limitations on when a generator may send out energy
  - compliance with dispatch instructions
  - the technical performance standards that apply for the connection of generators to the power system.
- Section D.2. covers other proposed changes that do not directly relate to provision of PFR, including:
  - AEMO's responsibility to maintain and improve power system security
  - the arrangements in the NER for inertia and inertia support activities.

D.1 Other changes related to primary frequency response

The rule change requests from AEMO and Dr. Sokolowski each propose a number of other changes to the NER that relate to the provision of PFR. The rule change requests propose changes to:

- Clause 3.15.6A(k) — relating to the determination of a contribution factor for the allocation of costs for regulating services
- Clause 4.9.4 — relating to the dispatch limitations that set out the conditions under which a scheduled and semi-scheduled generator may send out energy from its generation unit
- Clause 4.9.8 — relating to the general responsibility for a market participant to comply with a dispatch instruction given to it by AEMO
- Schedule S5.2.5.11 — relating to the technical performance standards for frequency control that apply for the connection of generators to the power system
- Schedule S5.2.5.14 — relating to the technical performance standards for active power control that apply for the connection of generators to the power system.

The draft rule includes changes to NER cl 3.15.6A, cl 4.9.4, cl 4.9.8 and cl S5.2.5.11 that address the relevant issues raised in the rule change requests.

The draft rule does not include any changes to Schedule S5.2.5.14.

Each of these proposed changes are discussed in the following sections.

D.1.1 Contribution factors for allocation of regulation costs

AEMO´s regulation FCAS contribution factor procedure ('causer pays') is the mechanism by which AEMO recovers the cost of regulation FCAS from Market Participants. Regulation services costs are allocated to Market Generators and Loads on the basis of their contribution factors calculated over a period of a month. These factors reflect the degree to which the generators actual output or, in the case of a scheduled load, their actual demand, differ from the targets assigned by the NEM dispatch engine (NEMDE).

Under this procedure, a positive contribution factor represents a generation portfolio that, on aggregate, helped to manage disturbances in power system frequency, while a negative contribution factor denotes a generation portfolio that, on aggregate, contributed to deviations in power system frequency. A positive net contribution factor indicates a generator will not be allocated a portion of the costs of regulation FCAS.

Dr. Sokolowski has proposed changes to clause 3.15.6A(k)(5) to clarify that, for the purposes of determining a contribution factor for the allocation of regulation FCAS costs, a market participant is expected to achieve its dispatch targets at a uniform rate subject to the provision of PFR. This proposed change is intended to clarify that provision of PFR should not be judged to be contributing to the need for regulation services. [191]

Stakeholder comments

Ergon Energy and Energex generally support the rules relating to removing disincentives to PFR as proposed by Dr Sokolowski.[192] Powershop also supports any changes to the Rules to remove disincentives to generators operating in frequency response mode and suggests an update to causer pays is necessary to align the causer pays process with these rule changes.[193]

However, CS Energy suggests Dr Sokolowski's amendment to clause 3.15.6A(k) may result in a change to the Causer Pays allocation calculations because it implies a different 'base' trajectory from which to calculate deviations. Given that the Causer pays procedure is a cost allocation process of secondary frequency control via regulating services, CS Energy consider that this change may have some unintended consequences. [194]

Commission's analysis and conclusion

The Commission considers that the proposed change clarifies the intent of the NER in relation to the determination of contribution factors for the allocation of regulating services. NER clause 3.15.6A(k) provides a set of principles to guide AEMO in its development of a procedure for the determination of contribution factors for the allocation of costs associated with regulating services. The primary principle is that:[195]

---

191 Dr. Sokolowski, Primary frequency response requirement — Electricity rule change proposal, 30 May 2019, pp.2, 7, 9, 12.

192 Ergon Energy and Energex, Submission to the *Primary frequency response rule changes* Consultation paper, 31 October 2019, p. 2

193 Powershop, Submission to the *Primary frequency response rule changes* Consultation paper, 31 October 2019, p. 5

194 CS Energy, Submission to the *Primary frequency response rule changes* Consultation paper, 31 October 2019, p. 18

195 NER Clause 3.15.6A(k)

(1) the contribution factor for a Market Participant should reflect the extent to which the Market Participant contributed to the need for regulation services;

Clause 3.15.6A(k) also includes sub-paragraph (5) and (7) that specify scenarios where a scheduled participant or a semi-scheduled generator respectively, will not be assessed as contributing to the deviation in the frequency of the power system.[196] These provisions set out that if, within a dispatch interval, a scheduled participant or a semi-scheduled generator "achieves its dispatch target at a uniform rate", it will not be assessed as contributing to the deviation in the frequency of the power system.[197]

AEMO has indicated that the wording of clause 3.15.6A(k)(5)(i) and (7)(i) of the NER creates the impression that strictly following dispatch targets irrespective of frequency outcomes is ideal behaviour.[198]

The Commission considers that the proposed change to 3.15.6A(k)(5)(i) clarifies that provision of PFR by a scheduled participant should not be judged to be contributing to the need for regulation services as is the intent of the Causer Pays procedure. The Commission also considers that the proposed change should be reflected in 3.15.6A(k)(7)(i) as it applies to semi-scheduled generators.

The draft rule includes the revision of clause 3.15.6A(k)(5)(i) to clarify that a scheduled participant will not be assessed as contributing to deviations in the frequency of the power system if:

3.15.6A(k)(5)

(i) subject to the provision of *primary frequency response* by that scheduled Participant in accordance with the *Primary Frequency Response Requirements*, the Scheduled Participant achieves its *dispatch* target at a uniform rate;

The draft rule includes the revision of clause 3.15.6A(k)(7)(i) to clarify that a semi-scheduled generator will not be assessed as contributing to deviations in frequency of the power system frequency if:

3.15.6A(k)(7)

(i) subject to the provision of *primary frequency response* by that *semi-scheduled generating unit* in accordance with the *Primary Frequency Response Requirements*, the *semi-scheduled generating unit* achieves its *dispatch level* at a uniform rate;

196 NER Clause 3.15.6A(k) (5) & (7).
197 NER Clause 3.15.6A(k) (5)(i) & (7)(i).
198 AEMO, Removal of disincentives to primary frequency response — Electricity rule change proposal, 1 July 2019, p.25.

D.1.2 Limitations on when a generator may send out energy

AEMO has proposed changes to the NER clause 4.9.4 in relation to the limitations on when a scheduled generator and a semi-scheduled generator may send out energy. The proposed changes to clause 4.9.4 clarify that both a scheduled and a semi-scheduled generator may send out energy from its generating unit as a consequence of operating in frequency response mode to adjust power system frequency in response to power system conditions.[199]

Dr. Sokolowski has also proposed changes to clause 4.9.4(a)(4) to clarify that both a scheduled and a semi-scheduled generating unit may send out energy as a consequence of operating in a frequency response mode. In addition, Dr. Sokolowski proposed alternative drafting to clarify that a generating unit's frequency response mode shall be subject to local power system conditions.[200]

Stakeholder comments

CS Energy does not believe that Dr. Sokolowski's changes to clause 4.9.4(a)(4) are necessary provided the clauses "are not given their literal meaning".[201]

Delta Electricity supports the changes to clause 4.9.4 to address disincentives to PFR in the rules.[202]

Powershop, Enel X, TasNetworks, Enel Green Power, and Ergon Energy and Energex generally support the proposed rule changes relating to clarification of the application of NER clause 4.9.4 as proposed by AEMO. [203]

Commission's analysis and conclusion

The Commission agrees with AEMO and Dr. Sokolowski that the proposed changes to clause 4.9.4 clarify that both scheduled and semi-scheduled generators can send out energy as a result of being frequency responsive. The Commission considers it desirable that all types of generators may provide PFR to the best of their capability. The provision of PFR involves the variation of the active power supplied by a generator to the grid and it is a common requirement for all generation plant to have this capability.[204]

The draft rule includes changes to clause 4.9.4(a)(3) that align with the proposals from AEMO and Dr. Sokolowski, including the addition of clause 4.9.4(a)(3A) stating both scheduled and semi-scheduled generators may send out energy:

> 4.9.4(a)
>
> (3A) as a consequence of its operation in *frequency response mode* to adjust *power*

199 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, pp.13, 45, 62.

200 Dr. Sokolowski, Primary frequency response requirement — Electricity rule change proposal, 30 May 2019, pp.3, 7, 9, 15.

201 CS Energy, Submission to the *Primary frequency response rule changes* Consultation paper, 31 October 2019, pg. 18

202 Delta Electricity, Submission to the *Primary frequency response rule changes* Consultation paper, 31 October 2019, pg. 20

203 Submissions on the consultation paper: Powershop, p. 5, Enel X, p. 7, TasNetworks, p. 3, Enel Green Power, p. 2, Ergon Energy and Energex, p. 2

204 NER Clause S5.2.5.11

system frequency in response to *power system* conditions; or

D.1.3 Frequency response and compliance with dispatch instructions

AEMO proposed changes to clause 4.9.8 of the NER in relation to the interaction of compliance with dispatch instructions and the operation of plant in a frequency response mode. The proposed changes to clause 4.9.8 would clarify that operating in a frequency response mode does not constitute a breach of a generator's requirement to comply with its dispatch instructions.[205]

Stakeholder comments

AGL identifies the perception that PFR provision conflicting with compliance with dispatch instructions was a key factor that drove generators to become frequency unresponsive, especially considering the AER's enforcement of this compliance. Many stakeholders agreed with AEMO that the NER should be revised such that it is clear that generators providing PFR are not breaching the obligation for them to comply with dispatch instructions. [206]

Stanwell requested clarification as to whether the proposal that generators are not penalised for PFR provision extends to ramping requirements.[207]

CS Energy does not consider issues related to strict compliance with dispatch instructions to be a continuing disincentive to PFR. [208]

As noted above, Enel X, TasNetworks and Ergon Energy and Energex also generally support the proposed rule changes relating to removing disincentives to PFR as proposed by AEMO. [209]

Commission's analysis and conclusion

The Commission acknowledges the potential lack of clarity surrounding the relationship between a unit's compliance with dispatch instructions and the provision of PFR has caused concerns for many stakeholders. The Commission agrees with AEMO that the wording in clause 4.9.8 should be revised to clarify this matter.

The draft rule includes changes to clause 4.9.8 to clarify that operating a plant in a frequency response mode is compatible with a generators' obligation to follow its dispatch instructions.

4.9.8

(a1) A *Scheduled Generator* or *Semi-Scheduled Generator* is not taken to have failed to comply with a *dispatch instruction* as a consequence of its *generating unit*

205 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, pp.13, 45, 62.

206 Submissions on the consultation paper: AGL, p. 1, HydroTas, p. 2, Kate Summers, p. 2, Stanwell, p.7, Powershop, p. 3, AEC, p. 2, Origin, p. 4, IES, p. 6, ERM, p. 9, Enel Green Power, p. 1.

207 Stanwell, Submission to the *Primary frequency response rule changes* Consultation paper, 31 October 2019, pg. 7

208 CS Energy, Submission to the *Primary frequency response rule changes* Consultation paper, 31 October 2019, pg. 6

209 Submissions on the consultation paper: Enel X, p. 7, TasNetworks, p. 3, Enel Green Power, p. 2, Ergon Energy and Energex, p. 2

> operating in *frequency response mode* to adjust *power system frequency* in response to *power system* conditions.

D.1.4 Changes to NER clause S5.2.5.11

Through its submission to the consultation paper, AEMO proposed changes to the S5.2.5.11 to align it with the new PFR requirement in clause 4.4.2A and the PFRR. AEMO's rule change request identifies that some generators interpret clause S5.2.5.11(i)(4) of the NER as supporting or requiring them to turn off or counteract their plants responsiveness to frequency unless they are enabled for the provision of FCAS.[210]

Stakeholder comments

CS Energy and TasNetworks both consider AEMO's proposed changes to S5.2.5.11 to be worthwhile. [211]

In its submission to the consultation paper, AEMO acknowledged the potential for unintended interpretations in relation to the new operational frequency control requirements in clause 4.4.2 (c1) and the *Primary frequency response requirements* (PFRR) alongside the existing frequency control requirement set out under clause S5.2.5.11.[212]

> AEMO considers that the capabilities required under the PFRR are not more onerous than the access standards in clause S5.2.5.11, or in other existing minimum access standards in clause S5.2.5.
>
> Nevertheless, AEMO recognises that two sets of requirements for frequency response could give rise to unintended interpretations.

AEMO included in its submission a proposed amendment to clause S5.2.5.11 to reduce the likelihood of any ambiguity. AEMO's proposed amendment includes a requirement under the automatic and minimum access standard in S5.2.5.11(b)(2) and S5.2.5.11(c)(2) for connecting generators to meet the requirements of the PFRR and removes the existing requirements in relation to the capability to set droop and deadband settings set out in S5.2.5.11(i)(2). [213]

Commission's analysis and conclusion

In relation to Dr Sokolowski's proposal to implement a mandatory requirement for PFR through clause S5.2.5.11, the Commission considers that an operational requirement for PFR is more appropriately implemented through chapter 4 of the NER as proposed by AEMO in its rule change request, *Mandatory primary frequency response*. The Commission considers that it is not appropriate to include an operational requirement in S5.2.5.11 as this rule sets out the frequency control capability requirements for connecting generators.

---

210 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, pp.13, 16-17, 45, 63.
211 Submissions on the consultation paper: CS Energy, p. 6, TasNetworks, p. 3
212 AEMO, Submission to the Consultation paper, 31 October 2019, pp. 6-7
213 Ibid., pp. 12-14

The Commission's considerations in relation to the inclusion of a mandatory PFR requirement in the NER are covered in appendix A.

Regarding AEMO's proposed changes to clause S5.2.5.11(i)(4), the Commission acknowledges that this clause has caused some concern to generators and may lead to difficulty interpreting a generator's responsibilities in relation to frequency control. This clause is part of the general requirements for frequency control that apply to connecting generators. It states that:[214]

> a generating system is required to operate in frequency response mode only when it is enabled for the provision of a relevant market ancillary service;

S5.2.5.11(i)(4) was introduced into the NER on 5 October 2018 following the publication of the *Generator technical performance standards* rule on 27 September 2018. The final determination for the *Generator technical performance standards* rule set out the rationale for the inclusion of this sub-paragraph in the NER. At that time, the Commission sought to clarify that the general requirements in S5.2.5.11 are for generators to demonstrate the capability to operate in frequency response mode as opposed to requiring a generator to operate in a frequency response mode and deliver an actual response. The drafting of this sub-paragraph was not intended to preclude or prevent a generator from operating in a frequency response mode when it is not enabled to provide FCAS. [215]

The Commission considers that, as S5.2.5.11(i)(4) has been misinterpreted to preclude a generator from operating in a frequency response mode when it is not enabled for a market ancillary service, there is likely to be a benefit in deleting this provision. The Commission considers that the requirements on generators to demonstrate frequency control capability are adequately specified by the remainder of S5.2.5.11 and that sub-paragraph (i)(4) does not improve the specification of the frequency control capability of a connecting generator. The draft rule deletes clause S5.2.5.11(i)(4).

The Commission has considered AEMO's proposal to amend S5.2.5.11 to link the minimum access standard to the requirements in the PFRR and remove the capability requirements for droop and deadband. AEMO's proposal is intended to address potential ambiguity between S5.2.5.11 and the operational frequency control requirements set out in Clause 4.2.4A and the PFRR. While the Commission acknowledges the need for clarification in relation to the requirements for frequency control capability set out in S5.2.5.11 and the operational requirement set out in Clause 4.2.4A, the Commission does not agree with AEMO's proposed changes for S5.2.5.11(b)(2) and S5.2.5.11(c)(2) to be subject to the PFRR and for the existing capability requirements for droop and deadband to be removed. The Commission considers that the frequency control capability requirements for connecting generators should be independent of the operational requirements and that these capability requirements should not be subject to AEMO's PFRR. Therefore, the draft rule does not include AEMO's proposed changes to S5.2.5.11(b)(2) and S5.2.5.11(c)(2), nor does it delete S5.2.5.11(i)(2).

---

214 NER clause S5.2.5.11(i)(4)

215 AEMC, *Generator technical performance standards* - Rule determination, 27 September 2018, p.58-59.

The Commission recognises the potential benefit in providing additional clarity in S5.2.5.11 in relation to the operational requirement for frequency control. The draft rule includes the following note after Clause S.5.2.5.11(b)(2) and S5.2.5.11(c)(2) in relation to the automatic and minimum access standards for frequency control:

> Note
>
> Clause 4.4.2(b) of the *Rules* sets out the obligations on *Generators* in relation to compliance with the technical requirements in clause S5.2.5.11, including being capable of operating in *frequency response mode*. Clause 4.4.2(c1) of the *Rules* sets out the obligations on *Scheduled* and *Semi-Scheduled Generators* in relation to the *Primary Frequency Response Requirements*.

D.1.5 Active power control

Dr. Sokolowski has proposed changes to clause S5.2.5.14 to clarify that a scheduled generating unit or a scheduled generating system should be capable of controlling its active power output "subject to local frequency". This clause sets out the active power control requirements that apply for Generators who are negotiating an agreement for the connection of a generating unit to the power system.[216]

Stakeholder comments

CS Energy commented on this proposed change by Dr. Sokolowski. CS Energy does not believe the changes to S5.2.5.14 are necessary provided the NER is interpreted as a whole while recognising the dynamic nature of the power system.[217]

Commission's analysis and conclusion

NER clause S5.2.5.14 sets out the technical performance standards that apply to connecting generators in relation to active power control. While active power control is related to the provision of frequency response, the Commission considers that it is not necessary for the active power control requirements to be explicitly linked to system frequency. The requirements for frequency control capability are specified in clause S5.2.5.11, including the minimum access standard that requires a generator to be capable of varying its power transfer to the power system in response to a rise or fall in power system frequency measured at the connection point.[218] Therefore, the Commission considers the proposed change to S5.2.5.14 does not provide a benefit in terms of improving the specification or clarity of the frequency control capability for connecting generators.

The draft rule does not include any change to S5.2.5.14.

---

216 Dr. Sokolowski, Primary frequency response requirement — Electricity rule change proposal, 30 May 2019, pp.3, 7-9, 21.
217 CS Energy, Submission to the *Primary frequency response rule changes* Consultation paper, 31 October 2019, pg. 6
218 NER Clause S.5.2.5.11(c)(2)

D.2 Other changes

Dr. Sokolowski has also proposed changes to certain clauses in the rules related to system security more generally, including proposed changes to:

- NER Clause 4.3.1 — relating to AEMO's responsibilities for power system security
- NER Clause 5.20B.5 — relating to the definition of inertia and inertia support activities

The draft rule does not include any changes to these NER clauses. The following section describes the Commission's considerations in relation to each of these proposals.

D.2.1 AEMO's responsibility for power system security

Dr. Sokolowski has proposed a revision to clause 4.3.1 of the NER to align it with S49(1)(e) of the NEL and clarify that AEMO is responsible not only to maintain power system security but also to improve it. [219]

Stakeholder comments

Most stakeholders did not support the proposed change to NER clause 4.3.1. One exception was Powershop who agreed with the intent of Dr. Sokolowski's proposed change to clause 4.3.1.[220]

Ergon Energy and Energex commented that the proposed changes risk creating an "open statement" in relation to the obligations placed on AEMO, potentially leading to adverse impacts on customers.[221]

AEMO and Delta Electricity also do not consider Dr. Sokolowski's change to clause 4.3.1 to be necessary. [222]AEMO noted that:[223]

> As with the other functions listed in section 49 of the National Electricity Law, they are high-level, and the detail around each function is in the NER. [...] Replicating that function in clause 4.3.1 of the NER will not achieve the desired outcome.

CS Energy considered there to be no benefit in the proposed amendment to NER clause 4.3.1 given AEMO's requirement to improve power system security under NEL.[224]

Commission's analysis and conclusion

In relation to Dr. Sokolowski's proposal, the Commission notes that, in addition to AEMO's direct obligation under the NEL, the requirement for AEMO to maintain and improve power system security, consistent with its obligations under the NEL, is reinforced through NER clause 4.1.1(b).

---

219 Dr. Sokolowski, Primary frequency response requirement — Electricity rule change proposal, 30 May 2019, pp.3, 7-9, 12.
220 Powershop, Submission to the Consultation paper, 31 October 2019, p. 6.
221 Ergon Energy and Energex, Submission to the Consultation paper, 31 October 2019, p. 2.
222 Submissions to the consultation paper: AEMO, p. 10, Delta Electricity, p. 13.
223 AEMO, Submission to the Consultation paper, 31 October 2019, p.10.
224 CS Energy, Submission to the Consultation paper, 31 October 2019, p. 16

> 4.1.1 (b) By virtue of this Chapter and the National Electricity Law, AEMO has responsibility to maintain and improve power system security.

The Commission considers that in the context of the existing reference under clause 4.1.1(b), the proposed change does not constitute a material benefit in terms of the understanding or the application of the NER.

The draft rule does not include any revision to NER clause 4.3.1.

D.2.2 Inertia support activities

Dr. Sokolowski's proposed rule also includes changes to the NER clause 5.20B.5(a) to include an explicit reference to the provision of fast frequency response (FFR) from inverter-connected plant being an included inertia support activity. Dr. Sokolowski also proposes a revision to the chapter 10 definition of 'Inertia'. As noted in Dr Sokolowski's rule change request:[225]

> The proposed changes with respect to inertia support activities recognise that fast frequency response services available from inverter connected plant can be seen to be effectively equivalent to inertia support.

Stakeholder comments

Powershop does not consider the current framework for inertia support activities adequately supports the use of FRR by inverter connected plant and so agrees with Dr Sokolowski's proposed change to the definition of inertia.[226]

However, TasNetworks and Energy Networks Australia do not agree with Dr Sokolowski's proposed changes to the definition of inertia on the grounds that FFR is not interchangeable with inertia and must be clearly differentiated from inertia provided by "traditional" rotating machinery. Instead, both TasNetwroks and Energy Networks Australia suggested alternative revision to the definition of inertia support services by adding the bolded text below:[227]

> ***Inertia support activity***
>
> An activity approved by AEMO under clause 5.20B.5(a) which may include installing or contracting for the provision of frequency control services, installing emergency protection schemes, contracting with Generators in relation to the operation of their generating units in specified conditions, **and installing or contracting fast frequency response delivered from inverter connected equipment.**

AEMO's noted that: [228]

> An inertia framework has recently been created, with mechanisms for inertia

225 Dr Sokolowski, Primary frequency response requirement — Electricity rule change proposal, 30 May 2019, p.8
226 Powershop, Submission to the *Primary frequency response rule changes* Consultation paper, 31 October 2019, pg. 6
227 Submissions on the consultation paper: TasNetworks, p. 6, Energy Networks Australia p. 2.
228 AEMO, Submission to the *Primary frequency response rule changes* Consultation paper, 31 October 2019, pg. 10

> management. AEMO does not consider that any changes to the inertia framework are necessary for determining these PFR rule change proposals.

CS Energy and Ergon Energy and Energex considers that any reconsiderations of inertia and inertia support activities are complex and should be pursued separately to the current rule changes.[229]

Commission's analysis and conclusion

In relation to the proposed change to NER clause 5.20B.5(a), the Commission notes that the existing clause 5.20B.5(a) specifies that 'inertia support activities' may be provided to help AEMO to operate the power system in a satisfactory and secure operating state. The provision of 'inertia support activities' may be taken into account by AEMO to reduce the minimum requirement for inertia network services provided by either a synchronous generating unit or a synchronous condenser as per NER clause 5.20B.4(d). The following note is included in the NER following clause 5.20B.5(a)(3):[230]

> If approved by AEMO under paragraph (a), inertia support activities may include installing or contracting for the provision of *frequency* control services, installing emergency protection schemes or contracting with *Generators* in relation to the operation of their *generating units* in specified conditions.

Clause 5.20B.5(a) allows for frequency control services, from inverter connected plant or otherwise, to be considered as 'inertia support activities' subject to approval by AEMO. The Commission notes that the existing arrangement for inertia support activities are inclusive of fast frequency response from inverter connected plant under the term, frequency control services. Therefore, the Commission do not consider there to be a benefit in making the proposed change to NER clause 5.20B.5(a).

In relation to the proposed change to the Chapter 10 definition of inertia, the Commission notes that the existing definition reflects the current operational approach that differentiates between physical inertia provided by synchronous machinery and fast frequency response provided by inverter connected equipment. The existing definition of inertia in the NER is:[231]

> Contribution to the capability of the *power system* to resist changes in *frequency* by means of an inertial response from a *generating unit, network element* or other equipment that is electro-magnetically coupled with the *power system* and *synchronised* to the *frequency* of the *power system*.

The Commission considers that inertia and fast frequency response are distinct services which perform different roles in the management of system frequency. Physical inertia from synchronous machines inherently slows the rate of frequency change caused by a contingency event. This is different to FFR, which actively injects power or reduces

229 Submissions on the consultation paper: CS Energy, p. 16, Ergon Energy and Energex p. 2
230 NER clause 5.20B.5(a)
231 NER Chapter 10

consumption to arrest the frequency change and revert the frequency back towards normal operating levels. Technologies that are capable of acting as a direct substitute for inertia by instantaneously and continuously maintaining local frequency have not yet been demonstrated as being reliable for operation at scale in large power systems. However, research suggests that these technologies are likely to become available for use in large power systems in the future.

The Commission considers that the existing definition of inertia reflects the current operational practise that differentiates between physical inertia provided by synchronous machines and fast frequency response provided by inverter connected plant. The proposed change would remove that distinction and result in inertia being a more general term that included any plant that is able to oppose a change in power system frequency.

The draft rule does not include any change to the chapter 10 definition of inertia.

E 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.

E.1 Draft rule determination

In accordance with s.99 of the NEL the Commission has made this draft rule determination in relation to the rules proposed by AEMO and Dr. Sokolowski (which were consolidated by the Commission under s99 of the NEL on 19 December 2019).

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

A copy of the more preferable draft rule is attached to and published with this draft rule determination. Its key features are described in chapter 4 and in further detail in Appendix A to D.

E.2 Power to make the rule

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

- the operation of the NEM
- the activities of persons (including Registered Participants) participating in the NEM or involved in the operation of the national electricity system
- The operation of the national electricity system for the purposes of the safety, security and reliability of the system

E.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
- the ongoing package of work being undertaken by the Commission in relation to frequency control frameworks.

There is no relevant Ministerial Council on Energy (MCE) statement of policy principles for this rule change request.[232]

232 Under s.33 of the NEL the AEMC must have regard to any relevant MCE statement of policy principles in making a rule. The MCE is referenced in the AEMC's governing legislation and is a legally enduring body comprising the Federal, State and Territory Ministers responsible for energy. On 1 July 2011, the MCE was amalgamated with the Ministerial Council on Mineral and Petroleum Resources. The amalgamated council is now called the COAG Energy Council.

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 AEMO's declared network functions.[233] The more preferable draft rule is compatible with AEMO's declared network functions because as it leaves those functions unchanged.

E.4 Civil penalties

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/NGR/NERR be classified as civil penalty provisions.

The Commission's draft more preferable rule includes the addition of rule 4.4.2(c1) into the NER. The new provision that the Commission is recommending to the COAG Energy Council as civil penalty provisions is:

> (c1) Each *Scheduled Generator* and *Semi-Scheduled Generator* must operate its *generating system* in accordance with the *Primary Frequency Response Requirements* as applicable to that *generating system*;

The Commission considers that this new provision should be classified as a civil penalty provisions because it will encourage compliance by the relevant parties. In addition, it is consistent with rule 4.4.2(b), which obliges a Generator's to ensure that all its generating units meet the technical requirements for frequency control in clause S5.2.5.11, and which is already classified as a civil penalty provision.

E.5 Conduct provisions

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

The draft rule does not amend any rules that are currently classified as conduct provisions under the NEL. The Commission does not propose to recommend to the COAG Energy Council that any of the proposed amendments made by the draft rule be classified as conduct provisions.

233 Section91(8) of the NEL.

F SUMMARY OF OTHER ISSUES RAISED IN SUBMISSIONS

This appendix contains the Commission's response to issues raised by stakeholders that have otherwise not been discussed in the main body of this document.

Table F.1: Summary of other issues raised in submissions

STAKEHOLDER	PAGE REFERENCE	ISSUE	AEMC RESPONSE
Snowy Hydro	p.1	Snowy believes that the proposed rule may conflict with Section 51(xxxi) of the Australian Constitution and recommends the AEMC should seek legal advice on the matter. *"Section 51(xxxi) of the Australian Constitution empowers the Commonwealth to make laws with respect to "the acquisition of property on just terms from any State or person for any purpose in respect of which the Parliament has power to make laws...". ...The mandatory nature of the PFR and the direct benefit to AEMO as a result of the PFR strongly suggests it involves an acquisition of property, enlivening s51(xxxi). If that is correct, then the proposed compensation arrangements must be on "just terms" (as understood in Constitutional jurisprudence), or otherwise the PFR requirements risks being found constitutionally invalid."*	1. Section 51(xxxi) of the Constitution applies in relation to the NER as applied in the offshore areas of the States and Territories, and by equivalent Commonwealth legislation to the NER as applied in the Territories. However, it does not apply in relation to the NER as applied in the participating States. 2. The prohibitions that apply in the offshore areas and the Territories do not constitute a general limit on the AEMC's rule-making power. 3. The draft rule does not amount to an acquisition of property as it does not constitute (a) a modification or extinguishment of property rights; and (b) a corresponding acquisition of property rights.

STAKEHOLDER	PAGE REFERENCE	ISSUE	AEMC RESPONSE
Stanwell	pp. 4-5, 7	Stanwell also considers that the proposed rule would result in the headroom reserved by their generators to meet ramping requirements will be utilised for PFR. Stanwell asks for clarification as to whether the proposal that generators are not penalised for PFR provision extends to ramping requirements. Stanwell does not believe the proposed rule to be technology neutral as some generators, such as solar and wind, do not naturally preserve headroom and so will not provide PFR.	The Commission considers that a generator's obligation to comply with dispatch instructions encompasses the generator's ramping requirements and that this obligation is subject to the provision of PFR, as discussed in Appendix D. The Commission considers the draft rule to be technology neutral as it applies a universal obligation on all scheduled and semi-scheduled generators that are not exempt, subject to energy availability.
Alinta	p.3	Alinta suggests fast ramping capabilities of large generators may be affected by the proposed rule change.	The Commission considers that a generator's obligation to comply with dispatch instructions encompasses the generator's ramping requirements and that this obligation is subject to the provision of PFR, as discussed in Appendix D.
IES	pp. 10-11	IES recommends a mechanism similar to a two-sided version of causer pays is implemented as soon as possible. IES recommends to: "Begin development work immediately on a prototype meter and settlement logic that would support wider participation in the proposed PFC market by any party, as well support any longer-term deviation pricing arrangement (through enhancement of the firmware)"	The Commission intends to consider the development of an effective valuation and payment mechanism for PFR through the assessment of the Removal of disincentives to the provision of primary frequency response rule change.

STAKEHOLDER	PAGE REFERENCE	ISSUE	AEMC RESPONSE
Infigen	p.3	Inifigen proposes that AEMO pursue the following approach: "AEMO could: - Initially, seek a mandatory response from large synchronous units (200 MW+) and observe the resulting frequency performance (6-12 months); - If insufficient, then seek response from smaller synchronous units; - Finally, if performance is still unsatisfactory and a market mechanism has not been developed, seek response from non-synchronous units, where cost of provision is likely to be highest."	The Commission has made this draft rule based on advice from AEMO, that this reform will meet the immediate system need for effective frequency control in the NEM. However, the Commission also recognises that further reform will be needed in the future and will be considered through the Removal of disincentives to the provision of primary frequency control rule change.
ERM Power	pp.2, 10.	ERM suggests that AEMO should request the FOS to be reviewed as it's first priority in addressing frequency performance. ERM suggests the following approach to addressing frequency performance: - Amend the Rules such that regulation FCAS can be supplied by AGC systems and PFR, as well as clarifying by which methods contingency FCAS must be provided. - Insert a requirement into the Rules obligating all generators to provide PFR outside of the band from 49.60Hz to 50.40Hz. - Rule changes mandating PFR should be put on hold "pending completion of the trial and research process as envisaged by the Frequency control framework review".	The Commission considers that further work needs to be done to understand the power system requirements for maintaining good frequency control and that this analysis should be undertaken through the second stage of the primary frequency response rule change process, the assessment of AEMO's Removal of disincentives to the provision of primary frequency response rule change request.

STAKEHOLDER	PAGE REFERENCE	ISSUE	AEMC RESPONSE
Energy Networks Australia	p.2.	Energy Networks Australia suggests that a market mechanism may be required in the future but should be considered by the ESB in its post 2025 market design work.	As discussed in section 3.4 and appendix G, all market bodies intend to work collaboratively with the ESB's Post-2025 Market Design plan in ongoing reform of frequency control frameworks.
ARENA	p.2.	ARENA suggests any price signals for PFR should be based on the causer pays principles. When designing any future frameworks, ARENA encourages the AEMC to consider: - the volume of PFR required on a regional basis - how the need for PFR may be reduced - potential changes to the capability and composition of the generation fleet, including the role of DER.	The Commission considers that further work needs to be done to understand the power system requirements for maintaining good frequency control and that this analysis should be undertaken through the second stage of the primary frequency response rule change process, the assessment of AEMO's *Removal of disincentives to the provision of primary frequency response* rule change request.
Delta Electricity	p.6.	Delta Electricity believes any frequency control objective should be defined by standards determined by the Reliability panel, implemented through clearly specified markets and subject to rigorous performance monitoring. Delta Electricity believes mandating security controls is only appropriate after all market options are exhausted, backed by sufficient evidence. Delta Electricity considers a redesigned MASS would deliver a more efficient solution than mandated Rules.	The Commission considers that further work needs to be done to understand the power system requirements for maintaining good frequency control and that this analysis should be undertaken through the second stage of the primary frequency response rule change process, the assessment of AEMO's *Removal of disincentives to the provision of primary frequency response* rule change request.
Neoen	pp.1-2, 3.	Neoen request an assessment of how PFR will be operationally managed and interact with current FCAS	The Commission considers that further work needs to be done to understand the power

STAKEHOLDER	PAGE REFERENCE	ISSUE	AEMC RESPONSE
		markets as well as the simultaneous creation of an FFR market. Neoen expects this analysis, including an assessment of the quantity of PFR required, to be carried out prior to implementing a significant rule. "AEMO should specify the magnitude of response expected within the NOFB. Then that capacity can be bought via auction, with more responsive plant able to offer a larger portion of rated capacity into the auction." Neoen considers regional reserves for contingency to be a issue relating to the reclassification of contingency events and not a requirement for PFR. Neoen supports a spot market for PFR services to be developed alongside a secondary contract market.	system requirements for in relation to frequency control. This analysis will be undertaken through by AEMO as part of the frequency control work plan as discussed in chapter 3.
AEC	pp.3, 10, 11-12	The AEC considers AEMO's proposals not to be an appropriate solution for steady state stability of the power system (as opposed to resilience). Instead, the AEC recommends: - Greater use of secondary control systems - Refinement of the MASS - Strengthening of the causer pays mechanism AEC offers three prioritised approaches for the short-term preferable to AEMO's proposal: - Competitive tenders	The Commission considers that further work needs to be done to understand the power system requirements in relation to frequency control. This analysis will be undertaken through by AEMO as part of the frequency control work plan as discussed in chapter 3.

STAKEHOLDER	PAGE REFERENCE	ISSUE	AEMC RESPONSE
		- Partially regulated such as that used in the UK - Mandatory PFR with regulated payment The AEC also suggests that work is carried out to examine how the accuracy of forecasts for semi-scheduled generator output can be improved and causer pays can be strengthened to encourage use of battery storage by variable generation.	
Fluence	p.4.	"Fluence is willing to work closely with AEMO and AEMC to determine potential alternate solutions, be it regional procurement of FCAS via bilateral contracts, as done in other markets in similar situations, alternate market changes to AGC signals to ensure more accurate participation, or removing the disincentive for PFR, so more FCAS is bid into the market."	The Commission intends to consider the development of an effective valuation and payment mechanism for PFR through the assessment of the Removal of disincentives to the provision of primary frequency control rule change.
Neoen	p.4.	Neoen considers that a mandatory PFR obligation will make it more difficult for peaking plant to cover their contracts during a price spike. Neoen reasons that non-sheduled generation increases after a price spike and raises frequency. Scheduled and semi-scheduled generation online that is covered by the mandatory PFR requirement, such as peaking plant who prefer to operate at times of price spikes, would have to respond to the over-frequency environment by providing lower PFR, therefore causing a loss of energy output and resultant revenue. Neoen suggests a mandatory PFR requirement would exacerbate this effect.	The Commission considers that a mandatory approach applied to a broad cross-section of the generating fleet should mean that the impact on any individual generators is minimised. However, the Commission acknowledges Neoen's concern and considers further investigation is needed in the context of market participant categories and the responsibilities of non-scheduled generators. The Commission invites Neoen to expand on

STAKEHOLDER	PAGE REFERENCE	ISSUE	AEMC RESPONSE
			this concern in a submission to this draft determination.
TasNetworks	p.5.	TasNetworks suggests a simple mechanism in the short-term may be payment to PFR providers based on their positive causer pays contribution factors.	The Commission intends to consider the development of an effective valuation and payment mechanism for PFR through the assessment of the Removal of disincentives to the provision of primary frequency control rule change.
Energy Australia	pp. 2,6.	As an alternative to the proposed solution, Energy Australia suggests changes to the FOS and consideration of possible changes to the existing frameworks and markets to meet the new FOS. This may include changes to the causer pays arrangements as proposed by ERC0263.	The Commission considers that further work needs to be done to understand the power system requirements for in relation to frequency control. This analysis will be undertaken through by AEMO as part of the frequency control work plan as discussed in chapter 3.
Powershop	pp. 4,7.	Powershop highlights that hydro plant are subject to water release instructions which will impact their ability to provide PFR.	The Commission considers the exemption principles set out in the draft rule, as discussed in Appendix B, provide guidance to generators' discussions with AEMO regarding their obligations with relation to these types of constraints.
Enel X	pp.3,7.	Enel X does not consider adequate quantitative evidence has been provided by AEMO to determine whether a mandatory regulation is justified or whether all capable generators should be required to provide PFR. Enel X	The Commission considers that further work needs to be done to understand the power system requirements for in relation to frequency control. This analysis will be

STAKEHOLDER	PAGE REFERENCE	ISSUE	AEMC RESPONSE
		suggests the following steps to improving frequency performance in the NEM as an alternative to the proposed rule: - Remove disincentives to PFR - Improve AGC - Regional procurement of FCAS - Consideration of market based solutions	undertaken through by AEMO as part of the frequency control work plan as discussed in chapter 3.
Bruce Miller	pp. 2.	Bruce Miller considers that the current FCAS markets and causer pays procedure should be reformed. Bruce Miller points to the inefficient dispatch of FCAS during the 25 August 2018 event and notes that generators that did not follow the NEMDE signals in QLD despite their adverse impact on region frequency would have been penalised under the current causer pays mechanism.	The Commission considers that further work needs to be done to understand the power system requirements for in relation to frequency control. This analysis will be undertaken through by AEMO as part of the frequency control work plan as discussed in chapter 3.