AEMC

RULE

Australian Energy Market Commission

CONSULTATION PAPER

NATIONAL ELECTRICITY AMENDMENT (CLARIFYING MANDATORY PFR OBLIGATIONS FOR BIDIRECTIONAL PLANT) RULE 2023

3 AUGUST 2023

INQUIRIES

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Reference: ERC0364

ABOUT THE AEMC

The AEMC reports to the energy ministers. We have two functions. We make and amend the national electricity, gas and energy retail rules and conduct independent reviews for the energy ministers.

ACKNOWLEDGEMENT OF COUNTRY

The AEMC acknowledges and shows respect for the traditional custodians of the many different lands across Australia on which we all live and work. We pay respect to all Elders past and present and the continuing connection of Aboriginal and Torres Strait Islander peoples to Country. The AEMC office is located on the land traditionally owned by the Gadigal people of the Eora nation.

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SUMMARY

1 Australia's National Electricity Market (NEM) is at the forefront of the energy transition globally. It has one of the highest penetrations of inverter-based resources (such as wind, solar and batteries) worldwide, which are rapidly displacing thermal generation (coal and gas). The secure decarbonisation of the power system depends on the long-term, consistent and predictable delivery of widespread of primary frequency response (PFR) which supports the stable operation of the power system.

2 AEMO submitted a rule change request on 11 May 2023 to clarify the mandatory PFR obligations of scheduled bidirectional units (i.e. batteries with a capacity 5MW and greater) once the integrating energy storage system rule change commences on 3 June 2024. The Commission understands that AEMO's objective for this proposal is to clarify obligations on batteries to ensure that the future provision of PFR is not only sufficient in volume but also provided in a predictable and consistent way. This is necessary for accurate power system modelling that underpins the secure operation of the power system.

3 The AEMC has commenced its consideration of the request, and this consultation paper is the first stage. The consideration of this rule change builds on previous work completed by the Commission and the Reliability Panel to establish enduring arrangements for the long-term provision of PFR to maintain system security and facilitate the decarbonisation of the generation fleet. In particular the Commission notes that this proposal follows on the *Primary frequency response incentive arrangements rule 2022 (PFR Incentives Rule)*. The key elements of that rule were the confirmation of mandatory PFR obligations for scheduled and semi-scheduled generators supported by new double-sided frequency performance payment arrangements and related reporting obligations.

4 AEMO is currently developing the procedures and processes to implement the new frequency performance payment arrangements which will take effect from 8 June 2025. These new arrangements are designed to value PFR provided under the mandatory arrangement and are also expected to incentivise additional frequency response from plant that are not covered by the mandatory PFR obligation. Potential providers of voluntary frequency response include non-scheduled generation and bidirectional units as well as scheduled or non-scheduled load. There is also the potential that aggregated consumer energy devices (CER) could play a role in the provision of PFR through virtual power plants (VPPs).

5 The Commission is aware that stakeholders may have concerns around the continued consideration of mandatory PFR obligations at this time. However, the focus of AEMO's rule change request is on the arrangements for PFR that relate to batteries. Clear regulatory arrangements, where practical, should act to reduce the overall perceived financial risk faced by potential investors in power system plant. It is therefore important to provide this certainty by considering this rule change request, given the key role that batteries are expected to play in the future power system.

6 As such, the Commission is seeking stakeholder feedback on AEMO's proposals as well as other options to determine if they would promote the long-term interests of consumers. Our objective is to clarify and confirm the obligations of batteries registered as scheduled

bidirectional units prior to their widespread deployment throughout the NEM.

AEMO's rule change request identifies two issues related to the provision of PFR

7 In its rule change request, AEMO has identified a concern that the existing mandatory PFR and PFR incentive arrangements may not be sufficient to support effective control of power system frequency over the long-term due to not having clear arrangements for scheduled bidirectional units. The Commission considers that the key challenges identified in AEMO's rule change request can be summarised as:

- issue 1 — the non-inclusion of scheduled bidirectional units in the mandatory PFR obligations when discharging
- issue 2 — uncertainty surrounding the long-term provision of consistent and predictable PFR, driven by unclear obligations on scheduled bidirectional units.

8 AEMO's rule change request proposes amendments to the NER to clarify the obligations for batteries registered as scheduled bidirectional units to provide PFR when discharging, charging and when enabled to provide a frequency control ancillary service (FCAS). AEMO considers that clarifying the frequency response obligations for bidirectional units is important as batteries are expected to play a crucial operational role in the future power system, especially during operation of the system dominated by renewable generation coupled with low operational demand. In the *Engineering Framework* AEMO projects that renewable energy resource potential will be sufficient to meet 100% of operational demand for isolated periods by 2025 and that such periods will be increasingly common in the future.

9 Chapter 2 of this consultation paper outlines these issues in more detail and seeks stakeholder feedback on the materiality of these key challenges. Stakeholder feedback will contribute to the Commission's assessment of which course of action is in the long-term interests of consumers.

We are seeking your views on the proposal to clarify that scheduled bidirectional units are required to provide PFR when discharging

10 AEMO proposes amendments to the NER that would act to retain the current obligations placed on batteries registered as scheduled generators to also be required to provide PFR when discharging as a scheduled bidirectional units after the 3 June 2024 when the *Integrating energy storage systems into the NEM* rule 2021 (IESS rule) commences. AEMO considers that the proposed change corrects an inadvertent drafting omission and would clarify that the rapidly growing fleet of batteries in the NEM continue to be required to provide PFR.

11 The Commission's preliminary view is that this change would be consistent with the outcome of the mandatory PFR and PFR incentive arrangements rules for the obligation on dispatched generators to comply with the Primary frequency response requirements (PFRR) to apply to scheduled bidirectional units as it does to scheduled or semi-scheduled generators. We are

seeking stakeholder feedback on this issue.

We are also seeking your views on AEMO's proposal to require scheduled bidirectional units to provide PFR when charging or enabled for market ancillary services

12 AEMO proposes to extend the mandatory PFR obligations to scheduled bidirectional units consuming electricity or enabled for market ancillary services. AEMO's rule change request states that the proposed changes would promote the long-term provision of sufficient, predictable and consistent PFR as thermal generation is progressively replaced by inverter-based resources and battery storage.

13 The Commission recognises that these proposed changes go beyond the existing obligation for scheduled and semi-scheduled generators to provide PFR when generating and are likely to impose material costs for batteries operating in the NEM. We are interested in stakeholder views on the materiality of these costs for batteries that are charging from the grid or providing contingency or regulation FCAS. We are also interested in views on other alternatives - as set out below - that seek to achieve the same system outcomes but at potentially lower impact on battery operators.

We are seeking your views on other, more incremental changes to promote long-term, consistent and predictable PFR

14 In addition to the solutions proposed by AEMO, the Commission will consider whether other, more incremental changes to that proposed by AEMO, coupled with the commencement of frequency performance payments, could help address the issues identified in the rule change request and support system security by promoting the long-term and consistent provision of PFR. These alternatives, which would build on the existing arrangements, include considering:

- voluntary registration of frequency response settings to benefit from the incentive arrangements
- revisions to the rules to require semi-scheduled generators seek AEMO approval prior to changing frequency response mode.

15 The Commission notes that further amendments to the NER in separate rule change projects are currently under consideration that have the potential to complement the new frequency performance payments. They could unlock additional market response to frequency thereby improving control of power system frequency and reducing reliance on scheduled or semi-scheduled generators. These related processes include:

- The *Integrating price-responsive resources into the NEM* rule change — which is considering the potential inclusion of a new "Light Scheduling Unit" registration category, or similar, to facilitate the voluntary integration of non-scheduled price responsive resources into market dispatch.[1]

1 See: https://www.aemc.gov.au/rule-changes/scheduled-lite-mechanism

- The *Unlocking CER benefits through flexible trading* rule change — is considering opportunities to improve flexibility and flexible trading of Consumer Energy Resources (CER) to unlock value for consumers and the energy market. The two specific areas for the rule change that may intersect are opportunities for separately identifying and managing flexible CER, and flexible trading of CER with multiple service providers at large customer premises. This rule change is one of the many reforms seeking to achieve successful CER integration in the NEM that aims to deliver a more reliable and secure energy system that would benefit all consumers.[2]

We consider that there are five assessment criteria that are most relevant to this rule change request

16 Considering the NEO[3] and the issues raised in the rule change request, the Commission proposes to assess the rule change request against the system services objective and the following five assessment criteria. Stakeholder feedback is sought on the appropriateness of these assessment criteria.

17 The **system service objective** is to:

Establish arrangements to optimise the reliable, secure and safe provision of energy in the NEM, such that is it provided at efficient cost to consumers over the long-term, where 'efficient cost' implies the arrangements must promote efficient:

- short-run operation of
- short-run use of,
- longer-term investment in, generation facilities, load, storage, networks (i.e. the power system) and other system service capability.

18 The Commissions proposed assessment criteria for this rule change are:

- **Safety, security and reliability** – the operational security of the power system relates to the maintenance of the system within predefined limits for technical parameters such as voltage and frequency.
- **Decarbonisation** – the market and regulatory arrangements for frequency control should promote the secure and efficient decarbonisation of the NEM's generation fleet in line with targets announced by the Commonwealth and State governments.
- **Principles of market efficiency** – 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.
- **Innovation and 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.

2 See: https://www.aemc.gov.au/rule-changes/unlocking-CER-benefits-through-flexible-trading
3 Section 7 of the NEL.

- **Principles of good regulatory practice** – 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.

19 These criteria and their selection process are explained in detail in section 4.3.

20

Submissions are due by 31 August 2023 with other engagement opportunities to follow

21 There are multiple options to provide your feedback throughout the rule change process.

22 Written submissions responding to this consultation paper must be lodged with Commission by **Thursday, 31 August 2023** via the Commission's website, www.aemc.gov.au.

23 There are other opportunities for you to engage with us, such as one-on-one discussions or industry briefing sessions. See the section of this paper about "How to engage with us" for further instructions and contact details for the project leader.

How to make a submission

We encourage you to make a submission

Stakeholders can help shape the solutions by participating in the rule change process. Engaging with stakeholders helps us understand the potential impacts of our decisions and, in so doing, contributes to well-informed, high quality rule changes.

We have included consultation questions in this paper, however, you are welcome to provide feedback on any additional matters that may assist the Commission in making its decision.

How to make a written submission

Due date: Written submissions responding to this consultation paper must be lodged with Commission by **31 August 2023**.

How to make a submission: Go to the Commission's website, www.aemc.gov.au, find the "lodge a submission" function under the "Contact Us" tab, and select the project reference code **ERC0364**.[4]

You may, but are not required to, use the stakeholder submission form published with this consultation paper.

Tips for making submissions are available on our website.[5]

Publication: The Commission publishes submissions on its website. However, we will not publish parts of a submission that we agree are confidential, or that we consider inappropriate (for example offensive or defamatory content, or content that is likely to

4 If you are not able to lodge a submission online, please contact us and we will provide instructions for alternative methods to lodge the submission.

5 See: https://www.aemc.gov.au/our-work/changing-energy-rules-unique-process/making-rule-change-request/our-work-3

infringe intellectual property rights).[6]

Other opportunities for engagement

There are other opportunities for you to engage with us, such as one-on-one discussions or industry briefing sessions.

For more information, you can contact us

Please contact the project leader with questions or feedback at any stage.

Project leader:	Victor Stollmann
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Full list of consultation questions

QUESTION 1: ISSUE 1 — NON-INCLUSION OF SCHEDULED BIDIRECTIONAL UNITS IN THE MANDATORY PFR OBLIGATIONS WHEN DISCHARGING

- What are stakeholders views on the proposal to clarify the scheduled BDU's be required to provide PFR when discharging?
- Is it consistent with the Commission's final determination for Mandatory Primary frequency response rule for scheduled bidirectional units to be included in the mandatory obligations?

QUESTION 2: ISSUE 2 — LONG-TERM PROVISION OF PFR

- What are stakeholders' views on AEMO concerns in relation to the long-term provision of PFR?
- What are stakeholders' views on the role of bi-directional units in providing PFR?

QUESTION 3: ISSUE 1 — PROPOSAL TO INCLUDE SCHEDULED BIDIRECTIONAL UNITS IN THE MANDATORY PFR OBLIGATIONS

- Do stakeholders agree with the Commission's preliminary position that the proposal to require bi-directional units to provide PFR while discharging aligns with previous

6 Further information is available here: https://www.aemc.gov.au/contact-us/lodge-submission

determinations for scheduled semi-scheduled generators to be required to provide PFR while generating?

QUESTION 4: ISSUE 2 — STAKEHOLDER VIEWS ON AEMO'S PROPOSAL FOR SCHEDULED BIDIRECTIONAL UNITS TO BE REQUIRED TO PROVIDE PFR WHEN THEY ARE CONSUMING ELECTRICITY FROM THE GRID

- Do stakeholders agree with AEMO's proposal that scheduled bidirectional units should be required to provide PFR when charging?
- Do stakeholders agree with AEMO's assessment of the costs and benefits of the change?
- What are stakeholders views on the cost impacts for batteries providing PFR while charging?

QUESTION 5: ISSUE 2 — STAKEHOLDER VIEWS ON AEMO'S PROPOSAL FOR SCHEDULED BIDIRECTIONAL UNITS TO BE REQUIRED TO PROVIDE PFR WHEN ENABLED TO PROVIDE A MARKET ANCILLARY SERVICE

- What are stakeholders views on AEMO's proposal that scheduled bidirectional units be required to provide PFR when enabled for market ancillary services?
- Do stakeholders agree with AEMO's assessment of the costs and benefits of this change?
- What are stakeholders views on the impacts for a battery in providing PFR while:
  - enabled for regulation services?
  - enabled for contingency services?

QUESTION 6: ISSUE 2 — COMMISSION'S OTHER PROPOSED CHANGES TO PROMOTE THE LONG-TERM PROVISION OF PFR

- What are stakeholders views on the Commission's proposed amendments to promote consistent and predictable PFR?
- Are stakeholders aware of any other incremental changes that would help promote consistent and predictable PFR while aligning with the existing mandatory PFR obligation and the incoming Frequency performance payment arrangements?

QUESTION 7: IMPLEMENTATION CONSIDERATIONS OF REQUIRING SCHEDULED BIDIRECTIONAL UNITS TO COMPLY WITH THE PFRR WHEN DISCHARGING

- Do stakeholders consider that there are any further implementation costs that should be considered by the Commission when assessing extending the mandatory PFR obligations to scheduled BDUs while discharging ?

QUESTION 8: IMPLEMENTATION CONSIDERATIONS OF SOLUTIONS TO PROMOTE THE LONG-TERM PROVISION OF PFR

- What are stakeholders' views on the implementation considerations identified for BDU's to be required to provide PFR while charging and providing FCAS?
- What are stakeholders' views on the implementation considerations for the other incremental changes identified by the Commission to support predictable and consistent provision of PFR?

QUESTION 9: ASSESSMENT FRAMEWORK

- Do you agree with the proposed assessment criteria?
- Are there additional criteria that the Commission should consider or criteria included here that are not relevant?

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APPENDICES

TABLES

FIGURES

1 THE CONTEXT FOR THIS RULE CHANGE REQUEST

AEMO's rule change request, *Clarifying mandatory primary frequency response obligations for bidirectional plant*, proposes to clarify the obligations on scheduled bidirectional units (BDUs) to provide primary frequency response during different operating modes. AEMO considers it necessary that the obligation for scheduled BDU's to provide PFR be clarified prior to the IESS rule commencing on 3 June 2024.

This section provides an overview of AEMO's rule change request along with relevant context and background, including how this rule change would build on recent work.

This section sets out:

- Section 1.1 – AEMO's proposed amendments to the obligations placed on scheduled bidirectional units to provide PFR
- Section 1.2 – This rule change builds on previous work by the Commission and the Reliability Panel
- Section 1.3 – The Commission is seeking to resolve uncertainty surrounding the PFR obligations for scheduled bidirectional units
- Section 1.4 – Consultation process.

1.1 AEMO's proposed amendments to the obligations placed on scheduled bidirectional units to provide PFR

AEMO's rule change request identifies a need to clarify PFR obligations for scheduled bidirectional units in light of the recent IESS rule and the expected large-scale deployment of battery energy storage systems (BESS) in the NEM. AEMO considers that clarifications to the obligations of scheduled BDUs would promote power system security by ensuring that an adequate level of PFR is available to effectively control power system frequency.

AEMO's proposal states that the NEO could be better met by amending the NER to require scheduled BDUs to:

- Provide PFR when generating following the commencement of the IESS rule on 3 June 2024. AEMO's rationale for this request is that if batteries continue not to be required to comply with the PFRR when they are generating then this could increase reliance on other scheduled and semi-scheduled generators. This would have the impact of severely compromising control over power system frequency as the proliferation of storage accelerates.
- Comply with the primary frequency response requirements (PFRR) when charging from the network (acting as a load) or enabled for market ancillary services (e.g. FCAS). AEMO's view is that a battery's frequency control system should remain consistent whenever it is operating (whether dispatched to generate, charged or enabled for FCAS), subject to variations approved by AEMO. AEMO considers that the current arrangements limit the circumstances under which the PFRR applies to batteries, which could in the longer-term:

- substantially reduce the availability of units operating with PFR control settings; and
- result in batteries operating in the market with inconsistent control settings.

AEMO's rule change proposal can be found on the AEMC's project webpage.[7] Further details on the problems identified in the proposal and the proposed remedies are outlined in chapter 2 and chapter 3 respectively.

1.2 This rule change request builds on previous work undertaken by the Commission and the Reliability Panel

The consideration of this rule change request builds on previous work completed by the Commission and the Reliability Panel to establish enduring arrangements for the provision of PFR to maintain system security. Recent relevant projects include the:

- *Mandatory primary frequency response rule* 2020[8] which sought to promote power system security by introducing a mandatory obligation for scheduled and semi-scheduled generators to provide PFR.
- *Integrating Energy Storage Systems into the NEM rule* 2021[9] which introduced the new Integrated Resource Provider registration category to make it easier for energy storage systems to participate in the NEM. Under the IESS rule, standalone storage capable of linearly and smoothly transitioning from charging to discharging must be classified as a:
  - scheduled bidirectional unit if its capacity is 5MW and above
  - non-scheduled bidirectional unit, if its capacity is under 5MW.
- *Primary frequency response incentive arrangements rule* 2022 [10] which established an enduring framework for the long-term provision of PFR in the NEM by confirming the mandatory obligations and introducing frequency performance payments.
- *Reliability Panel review of the frequency operating standard* (FOS) 2022 [11] which revised the FOS to adapt to the changing nature of the power system as thermal generators are increasingly displaced by inverter based resources. The revised FOS confirmed the settings for normal operation, including the primary frequency control band (PFCB) that relates to the sensitivity for mandatory PFR provided by scheduled and semi-scheduled generators.

The Commission remains committed to these reforms given they have only recently been made and considers that they provide AEMO with the tools it needs to manage the secure operation of the power system in accordance with the technical limits specified in the FOS. In addition, the inclusion of incentive payments which will commence on 8 June 2025 aim to deliver more efficient operation of- and investment in- power system plant. This will occur by encouraging innovation and deployment of new capabilities that would deliver lower overall frequency control costs for consumers overs the longer-term.

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7 See: https://www.aemc.gov.au/rule-changes/clarifying-mandatory-primary-frequency-response-obligations-bi-directional-plant
8 See: https://www.aemc.gov.au/rule-changes/mandatory-primary-frequency-response
9 See: https://www.aemc.gov.au/rule-changes/integrating-energy-storage-systems-nem
10 See: https://www.aemc.gov.au/rule-changes/primary-frequency-response-incentive-arrangements
11 See: https://www.aemc.gov.au/market-reviews-advice/review-frequency-operating-standard-2022

A summary of the relevant rule change projects and the Reliability Panel review is available in appendix A.

The provision of primary frequency response (described in appendix B) has many benefits for frequency control, both during normal operation and following contingency events. However, the Commission also acknowledges that costs are incurred by generators and bidirectional units in providing this service.

As these technologies have started to form an increasingly large proportion of the supply mix, the mandatory PFR obligations require any scheduled or semi-scheduled generator to operate in frequency response mode when generating. As identified in AEMO's *Engineering Framework,* the reliable provision of PFR by inverter-based resources is crucial to enable the system secure operation at 100% instantaneous penetration of renewable.[12]

As outlined in appendix A, the costs and benefits from the provision of widespread narrow-band PFR have been thoroughly investigated by the Commission and Reliability Panel. Both the PFR incentive arrangements rule and 2022 review of the frequency operating standard projects supported the continuation of the current mandatory arrangements as a prudent solution to maintain satisfactory frequency control and thereby promote power system security. A summary of the costs and benefits of widespread narrow band PFR are found in appendix B.

1.3 The Commission is seeking to resolve uncertainty surrounding the PFR obligations for scheduled bidirectional units

The Commission is aware that stakeholders may have concerns that the continued consideration of obligations on batteries to provide PFR could increase the uncertainty around technical obligations and act to increase the perceived investment risk for investment in grid-scale battery energy storage systems. As such, the Commission is seeking stakeholder feedback on the proposal in AEMO's rule change request with the goal of clarifying the obligations for battery energy storage systems classified as scheduled bidirectional units. The Commission recognises that such clarity will be important for investors to understand as the penetration of batteries increases in the NEM.

In assessing AEMO's rule change request, the Commission seeks to:

- Identify and resolve any uncertainties in relation to the responsibilities of BDUs with respect to the provision of PFR. The intent is to minimise investor uncertainty in light of the expected accelerating deployment of batteries throughout the NEM.
- Investigate other, more incremental arrangements that would support the provision of consistent and predictable power system frequency response, including the options for the registration of voluntary frequency control settings by units interested in receiving frequency performance payments.

12 AEMO, Engineering Roadmap to 100% Renewables, December 2022.

1.4 We have started the rule change process

This paper is the first stage of our consultation process. The Commission invites stakeholders to make submissions on the stated problem and the proposed solutions.

A standard rule change request includes the following formal stages:

- a proponent submits a rule change request
- the Commission commences the rule change process by publishing a consultation paper and seeking stakeholder feedback
- stakeholders lodge submissions on the consultation paper and engage through other channels to make their views known to the AEMC project team
- the Commission publishes a draft determination and draft rule (if relevant)
- stakeholders lodge submissions on the draft determination and engage through other channels to make their views known to the AEMC project team
- the Commission publishes a final determination and final rule (if relevant).

The key dates for this process are outlined Table 1.1 below.

Table 1.1: Key project dates

MILESTONE	KEY DATES
Publication of consultation paper	3 August 2023
Close of submissions to the consultation paper	31 August 2023
Publication of draft determination (and draft rule)	2 November 2023 (planned)
Publication of final determination (and final rule)	25 January 2024 (planned)

Note: The Commission will consider the timing for the publication of the draft and final determinations based on stakeholder feedback to this consultation paper.

Information on how to provide your submission and other opportunities for engagement is set out at the front of this document.

You can find more information on the rule change process in *The Rule change process – a guide for stakeholders.*[13]

13 *The rule change process: a guide for stakeholders, June 2017, available here: https://www.aemc.gov.au/sites/default/files/2018-09/A-guide-to-the-rule-change-process-200617.PDF*

2 THE PROBLEM RAISED IN THE RULE CHANGE REQUEST

In its rule change request, *Clarifying mandatory primary frequency response obligations for batteries*, AEMO has identified a concern that the existing mandatory and incentive arrangements for primary frequency response may not be sufficient to support effective control of power system frequency over the long-term. In particular AEMO proposes changes to the NER that would clarify the obligation for batteries to adhere to the PFRR in different operating modes, including while discharging, charging and while enabled to provide a market ancillary service — in effect, enabled for frequency control ancillary services (FCAS).

AEMO considers that clarifying the frequency response obligations for batteries is important as they are expected to play a crucial operational role in the future power system, especially during operation of the system with 100% renewable generation. Periods with sufficient renewable energy resource potential in the NEM to meet 100% of operational demand are expected to begin in 2025 at the earliest and be increasingly common in the future.[14]

The following sections summarises the issues raised by AEMO in their rule change request:

- Section 2.1 – non-inclusion of scheduled bidirectional units in the PFR obligation when discharging
- Section 2.2 – uncertainty around the long-term provision of consistent and predictable PFR.

2.1 Issue 1 – Non-inclusion of scheduled bidirectional units in the PFR obligation when discharging

AEMO's rule change request identifies uncertainties in relation to the obligations that apply to scheduled bidirectional units to provide PFR. In particular, AEMO identified that following the commencement of the IESS rule in June 2024, batteries that were previously been classified as scheduled generating units will switch over to being classified as scheduled bidirectional units and will no longer be required to provide PFR.[15]

The Commission recognises that this outcome is the result of an inadvertent drafting omission and that it is consistent with the Mandatory PFR final determination and the PFR incentives final determinations for scheduled bidirectional units to provide PFR while discharging (generating).

The following section summarises the issue.

14 AEMO, Engineering Roadmap to 100% Renewables | FY2024 Priority actions, 10 July 2023, p.8.

15 Batteries with a storage capacity 5MW and greater will be reclassified as scheduled BDUs, below 5MW will be non-scheduled BDUs.

2.1.1 AEMO's rule change identifies the inadvertent omission of scheduled BDUs from the mandatory PFR obligations

In its rule change request, AEMO identifies the need to clarify the obligations of scheduled bidirectional units to adhere to the PFRR when generating. AEMO considers that omission of a requirement for scheduled BDUs to continue complying with the mandatory PFR obligations could present significant issue for maintaining frequency control in the power system, and could increase the burden placed on remaining scheduled and semi-scheduled generators.

AEMO's rule change identifies that:[16]

> The omission of the new IRP category and BDUs from NER 4.4.2(c1), 4.4.2A and 4.4.2B means that – without a rule change - batteries will not be subject to any PFR requirements once the IESS rule becomes effective on 3 June 2024

AEMO's request states that:[17]

> if not corrected, the omission of batteries would present significant issues for the frequency control of the power system, which would grow steadily with the installed capacity of registered batteries while the PFR obligation is borne solely by scheduled and semi-scheduled generators.

Once the IESS rule takes effect scheduled bidirectional units will no longer be required to provide PFR when discharging

As outlined in section 1.2, the IESS rule aimed to better facilitate the integration of storage and hybrid facilities in the NEM by introducing a new category of market participant – the Integrated Resource Provider. It sought to accommodate a variety of participants with bidirectional energy flows that may offer and consume energy and ancillary services, such as grid-scale storage, hybrids, aggregators of small generation and storage units.

Once the revised IESS framework commences, grid-scale storage larger than 5 MW will be reclassified as scheduled bidirectional units as they are capable of smoothly and linearly transitioning from charging to discharging (or vice versa).[18] Previously grid-scale storage system operated both as a scheduled generator and scheduled load depending on operating mode, requiring adherence to the PFRR when generating but not consuming energy. Once the new bidirectional unit classifications commence, the mandatory obligations on batteries will lapse.

AEMO's rule change request identifies that the Commission's overlapping development of the IESS and PFR incentive arrangements rules resulted in an inadvertent omission by not extending the mandatory PFR obligations to include scheduled BDUs, in addition to the existing requirements on scheduled and semi-scheduled generators.

16 Ibid., p.8.

17 Ibid., p.9.

18 The IESS rule introduced the new Integrated Resource Provider (IRP) category. Under the rule, an IRP must classify standalone storage — 5MW and above — as a scheduled bidirectional unit unless the unit does not transition linearly through zero. If the unit does not have that capability, the unit must remain classified as a scheduled generating unit and a scheduled load.

The rule change proposal outlines that:[19]

> Although the IESS Rule extended most NER obligations on scheduled generators to IRPs, it did not amend the PFR provisions in NER 4.4.2(c1), 4.4.2A and 4.4.2B. This was because, at the time of making the IESS Rule, these were scheduled to sunset before the IESS Rule amendments would commence in June 2024. This meant it would be necessary to incorporate an extension of these obligations to IRPs only when a decision was made to make mandatory PFR enduring (the PFR Incentives Rule was still under consideration by the AEMC at the time).

QUESTION 1: ISSUE 1 — NON-INCLUSION OF SCHEDULED BIDIRECTIONAL UNITS IN THE MANDATORY PFR OBLIGATIONS WHEN DISCHARGING

- What are stakeholders views on the proposal to clarify the scheduled BDU's be required to provide PFR when discharging?
- Is it consistent with the Commission's final determination for Mandatory Primary frequency response rule for scheduled bidirectional units to be included in the mandatory obligations?

2.2 Issue 2 – Uncertainty around the long-term provision of consistent and predictable PFR

In addition to rectifying the omission of scheduled BDUs from the mandatory PFR obligations when discharging (issue 1), AEMO's rule change request identifies a concern around the certainty that there will be sufficient PFR in the future to support system security on an ongoing basis.[20] AEMO's view is that::[21]

> As the installation of batteries continues in greater numbers and at larger scale, combined with the retirement of large thermal generating unit, their contribution to maintaining good frequency control via the provision of PFR will become increasingly important, and may be insufficient if excluded across significant periods of their operation.

AEMO has also identified the adequate availability of PFR as a priority action through its *Engineering framework.* The relevant pre-condition to operate the network at 100% instantaneous inverter based generation is that: [22]

> Frequency response and frequency control ancillary services (FCAS) reserve requirements completely met by VRE, storage, demand response and other non-fossil

19 Ibid.
20 Ibid., p.14.
21 Ibid., p.13.
22 AEMO, Engineering Roadmap to 100% Renewables, December 2022, pp.73-74.

> fuel technologies

AEMO noted that it would:[23]

> Assess narrow-band primary frequency response needs as increasing DPV displaces frequency responsive plant online in the daytime

AEMO's rule change request identifies that the rules currently only require batteries to adhere to the PFRR when operating as a scheduled generator. The rules do not require:

- battery energy storage systems to operate in frequency response mode when charging
- batteries enabled for market ancillary services to provide PFR when they have a zero dispatch target for energy.

AEMO's rule change proposal requests the Commission reconsider its previous determinations in light of the introduction of the new bidirectional unit category, the expected increase in the number of batteries connecting to the grid and the scheduled commencement of frequency performance payments in 2025.

In its rule change request, AEMO articulates that the existing rules:[24]

> inhibit the continuous application of PFRR control settings.

AEMO's concern is that the existing NER do not support future operational outcomes where control system settings are applied consistently and predictably and that this could undermine system security during future operational periods where there is a small volume of synchronous thermal plant online.[25]

AEMO considers that it is appropriate that all capable energy production technologies should comply with the PFRR and in particular that batteries be required to provide PFR irrespective of the type of dispatch instruction they receive. Battery energy storage systems have demonstrated the ability to provide a high quality frequency response across their full range of operating modes. Given the expectation for increasing volumes of batteries to be deployed over coming years, AEMO considers it a priority that batteries provide consistent and predictable PFR across their full range of operating modes when operating commercially in the NEM. AEMO does not propose that BDU's be required to provide PFR when at rest and note dispatched to generate electricity, consume electricity or provide a market ancillary service.[26]

The following subsections provide a summary of the issues described in the rule change request with respect to:

- Section 2.2.1 – the provision of PFR by bidirectional units when charging
- Section 2.2.3 – the provision of PFR by bidirectional units when enabled for FCAS.

23 Ibid.
24 Ibid., p.10.
25 Ibid., p.14.
26 Ibid., p.12.

Furthermore, section 2.2.3 describes the Commission's view that the Frequency performance payments — which commence in June 2025 — are intended to encourage additional primary frequency response, beyond the minimum requirement under the mandatory obligations. In the context of this, the Commission is seeing stakeholder feedback on other incremental changes to promote the provision of consistent and predictable PFR.

2.2.1 Provision of PFR by scheduled bidirectional units when charging

AEMO considers that all plant that are capable of providing PFR should be required to do so when operating commercially in the national electricity market.[27] While AEMO notes that the Commission's previous determinations were to not apply the PFR obligation to batteries that were charging, it considers that the introduction of the new registration category, "integrated resource provider" and the relevant plant category, "bidirectional unit" lay the grounds for reconsidering the application of the PFR obligation to bidirectional units when charging.

In its rule change request, AEMO identifies the changed circumstances that warrant the reconsideration of this issue are:[28]

- at the time the bidirectional unit classification had not yet been introduced and
- there was no pressing need to incorporate battery charging into the obligation given the expected sunset date of the arrangements.

The new bidirectional unit classification allows for continuous PFR settings across operating modes

AEMO's rule change request identifies that the IESS rule requires batteries to be reclassified and regulated as a single integrated unit – the bidirectional unit – distinct from a scheduled generator or scheduled load. AEMO's view is this change recognises their unique capabilities as bidirectional plant and the bidirectional capability also translates to the mandatory PFR obligations.

AEMO's proposal contends that revising the settings to ensure consistent frequency response settings across operating modes would benefit the system as:[29]

> Ideally all units should always operate with control settings consistent with the PFRR, and thus provide a continuous proportional response from the PFCB and throughout the full range of operating frequency. This should include those batteries enabled for contingency FCAS as proportional controllers.

As such, AEMO's rule change proposal asks the Commission to reconsider the obligations of scheduled bidirectional units to be required to provide PFR when charging. Thereby allowing for continuous frequency settings across charging and discharging operating modes.

AEMO's view is that the widened requirements would not discriminate against batteries as it would apply a consistent and technologically neutral obligation for all relevant plant to

27 Ibid., p.12.
28 Ibid., p.10.
29 AEMO rule change request, p.16.

operate with appropriate control systems. AEMO considers that the broadened requirements would provide certainty for battery developers and the market operator by confirming:[30]

> that control system settings are applied consistently and predictably, and not changed with different modes of operation unless a regulated approval process applies.

In addition, given batteries are operating commercially when charging or enabled for market ancillary services, AEMO considers that applying the requirement to comply with the PFRR would ensure the rules apply irrespective to how different technologies can provide market services. Importantly, the rule change request clarifies that AEMO is not proposing that BDUs be required to adhere to the PFRR when they are synchronised but not operating commercially. That is, they would not have to adhere to the PFRR if they are not charging, discharging or enabled for market ancillary services.

Further detail on AEMO's reasoning and proposal to extend the mandatory PFR obligation to scheduled bidirectional units while charging is set out in section 3.2.1.

2.2.2 Provision of PFR by scheduled bidirectional units when enabled for FCAS

AEMO's rule change request identifies that the changes to the NER, made as part of the *Mandatory primary frequency response* rule and confirmed through the *PFR incentive arrangements* rule, do not require units enabled for contingency FCAS to provide PFR unless they are given a non-zero dispatch instruction. In the mandatory PFR final determination, the Commission stated that:[31]

> Under the final [mandatory PFR] rule, a battery energy storage system could be operated at all times in a frequency responsive mode but have different pre-approved control system settings that applied depending on whether it is charging, discharging or at rest… when the system is dispatched for a value greater than zero MW, the applicable control settings would need to comply with AEMO's PFRR, whereas at other times the PFRR would not apply.

As outlined by AEMO's rule change request, under the requirements set out in the contingency FCAS market ancillary service specifications (MASS) batteries must only:[32]

> Respond once frequency exits a deadband no wider than the mainland intact system normal operating frequency band (NOFB) which is +/-0.15 Hz, and the response must be in proportion to the frequency deviation.

AEMO views the current requirements as inadequate as system frequency is likely not to exceed the NOFB when considering the ubiquity of primary frequency response, therefore:[33]

> AEMO considers it suboptimal for batteries enabled for FCAS in central dispatch to be

30 Ibid., p.14.
31 AEMC, Mandatory primary frequency response - final determination, p.88.
32 AEMO rule change request, p.15.
33 Ibid.

> providing no primary frequency response until system frequency enters the contingency band [outside the NOFB].

AEMO considers that the omission of a requirement for units to provide PFR when enabled for contingency FCAS amplifies the lack of control within the NOFB, resulting in:[34]

- Reduced immediacy of response, negatively affecting frequency control and recovery if there is a lack of available headroom on other units that are not enabled.
- Reduced predictability of response, since the dynamic provision of PFR could be subject to market outcomes, depending on the type of market participant enabled for contingency FCAS.
- Increased burdens on other units with available headroom to provide mandatory PFR including those enabled for market ancillary services.

In addition, AEMO identifies that the current carve-out from mandatory PFR for units providing FCAS, without a dispatch instruction, could result in perverse incentives, given that:[35]

> Reducing the burden on batteries, as opposed to other providers of FCAS, may have a negative effect of encouraging, at the margin, batteries to be enabled for regulation, contingency FCAS *or* to be dispatched for energy, rather than together.

2.2.3 Other more incremental changes that could promote the long-term provision of consistent and predictable PFR

The Commission notes that the new frequency performance payments arrangements – that commence on 8 June 2025 – are intended to encourage frequency response over and above the minimum requirements under the mandatory PFR requirement. This additional response could be delivered as a consequence of scheduled and semi-scheduled generators maintaining additional stored energy to provide PFR (which is not required under clause 4.4.2(c1) of the NER), or through PFR being provided by other market participants, such as non-scheduled generators, loads and bidirectional units that are not covered by the mandatory PFR obligation.

At the same time, the Commission recognises that there is a need for AEMO to have visibility over the frequency responsiveness of power system plant such that AEMO's power system models accurately reflect the real behaviour of the power system. The accuracy of power system models is a fundamental element in AEMO being able maintain system security by effectively predicting how the power system will respond to disturbances. As noted in AEMO's rule change request, the intention is:[36]

> that control system settings are applied consistently and predictably, and not changed with different modes of operation unless a regulated approval process applies.

34 Ibid., p.16
35 Ibid.
36 AEMO rule change request, p.14.

The Commission's preliminary views on other potential alternative options are discussed in section 3.2. We are after stakeholder views on these.

QUESTION 2: ISSUE 2 — LONG-TERM PROVISION OF PFR

- What are stakeholders' views on AEMO concerns in relation to the long-term provision of PFR?
- What are stakeholders' views on the role of bi-directional units in providing PFR?

3 THE PROPOSED SOLUTION

AEMO's rule change request proposes amendments to the NER to clarify the obligations for batteries registered as scheduled bidirectional units to provide PFR when discharging, charging and when enabled to provide a market ancillary service (FCAS). The changes seek to address the issues identified to ensure the long-term security of the power system. For the purposes of facilitating stakeholder consultation, we have grouped the solutions into two broad categories of proposed changes to the NER that relate to the two key issues identified in AEMO's rule change request:

- Section 3.1 – relates to issue 1 and describes AEMO's proposal to resolve the non-inclusion of scheduled bidirectional units in the PFR obligations when discharging.
- Section 3.2 – relates to issue 2 and describes AEMO's proposed changes to the NER to ensure the long-term provision of PFR as well as the Commission's consideration of other incremental solutions to promote consistent and predictable frequency response.

AEMO's rule change request includes proposed rule drafting.

Stakeholder feedback on this chapter will inform the Commission's consideration of AEMO's proposed solutions and any other solutions identified in submissions to this Consultation paper that may be in the long-term interests of consumers.

3.1 Issue 1 – proposal to include scheduled bidirectional units in the PFR obligation when discharging

AEMO proposes to address the first issue – outlined in section 2.1 of this paper – by clarifying the obligations of scheduled bidirectional units when discharging energy to the power system.

The Commission is seeking stakeholder feedback on the proposed solution and has outlined:

- AEMO's view that the current obligations on scheduled generators to comply with the PFRR when discharging should also apply to scheduled bidirectional units.
- that the proposed solution aligns with the Commission's previous consideration of the issue.

3.1.1 The current obligations placed on scheduled generators should apply to scheduled bidirectional units

The rule change request proposes to extend the existing PFR requirements placed on scheduled or semi-scheduled generators to also apply to scheduled bidirectional units. This would mean that battery energy storage systems that are registered as scheduled BDUs would continue to be required to comply with the PFRR when they are dispatched to generate electricity, just as they are currently required to, when registered as scheduled generating units.

AEMO's rule change request states that correction of this inadvertent drafting omission is required to ensure the rapidly growing fleet of batteries in the NEM continue to be required to provide PFR. [37]

3.1.2 The Commission's preliminary position recognises that applying the PFR obligation to discharging scheduled BDUs is consistent with previous determinations

The Commission preliminary position recognises that this outcome is the result of an inadvertent drafting omission and that the proposed solution would be consistent with the mandatory PFR and PFR incentive arrangements final determinations.

Under the mandatory PFR rule, when generating (discharging), battery energy storage systems were treated the same as other scheduled and semi-scheduled generators. The final rule requires:[38]

> 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.

The removal of the sunset provisions on the mandatory obligations – as part of the PFR incentive arrangements rule – confirmed the Commission's intention that the obligations on batteries – alongside scheduled and semi-scheduled generators – should endure alongside the introduction of frequency performance payments. The final determination stated that:[39]

> The final rule confirms that the mandatory PFR arrangements will endure beyond 4 June 2023 by removing the existing sunset provision for these arrangements. This means that all scheduled and semi-scheduled generators will continue to be required to support the secure operation of the power system by responding automatically to changes in power system frequency.

The Commission's preliminary position is that it would be consistent with the outcome of the mandatory PFR and PFR incentive arrangements rules for the obligation on generators to adhere to the PFRR when dispatched to apply consistently across the spectrum – to scheduled bidirectional units as it does to scheduled and semi-scheduled generators.

QUESTION 3: ISSUE 1 — PROPOSAL TO INCLUDE SCHEDULED BIDIRECTIONAL UNITS IN THE MANDATORY PFR OBLIGATIONS

- Do stakeholders agree with the Commission's preliminary position that the proposal to require bi-directional units to provide PFR while discharging aligns with previous determinations for scheduled semi-scheduled generators to be required to provide PFR while generating?

37 AEMO rule change request, p.10.
38 AEMC, Mandatory primary frequency response - final determination, 26 March 2020, p.45.
39 AEMC, Primary frequency response incentive arrangements - final determination, September 2022, p.1.

3.2 Issue 2 – future provision of consistent and predictable PFR

As described in section 2.2, AEMO has identified concerns in relation to the long-term provision of sufficient, predictable and consistent PFR as synchronous thermal generation is progressively replaced by inverter based renewable generation and battery energy storage. AEMO proposes to address this issue by extending the obligations for scheduled bidirectional units to provide PFR when:

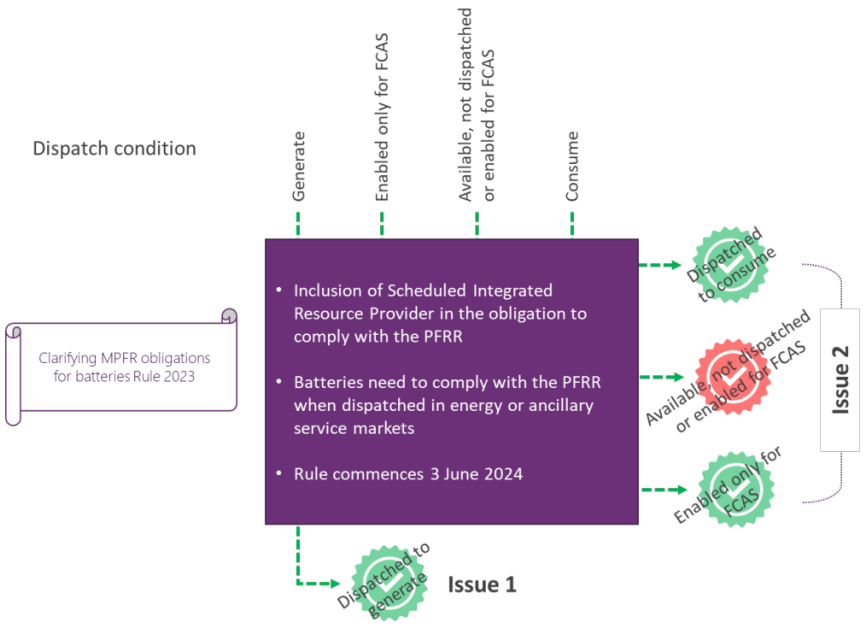
- dispatched to consume electricity (i.e. operating as a load), or
- enabled for market ancillary services (i.e. enabled for regulation or contingency FCAS).

AEMO considers that the proposed changes are necessary to provide ongoing frequency control capability to support power system security into the future, as the NEM's generation fleet continues to decarbonise. AEMO notes that:[40]

> extending the obligation of mandatory PFR to these resources now ensures the operational and regulatory frameworks that underpin the secure and reliable supply of electricity recognises these resources and appropriately utilises their contribution to maintain good frequency control into the future.

Figure 3.1 illustrates the AEMO's proposed revised obligations for provision of PFR by scheduled BDUs.

Figure 3.1: AEMO's proposed remedy to the issues outlined in their rule change request



Source: AEMO rule change request, p.13.

40 AEMO rule change request, p.19.

The Commission recognise that these proposed changes go beyond the existing obligation for scheduled and semi-scheduled generators to provide PFR when generating and are likely to impose material costs for batteries operating in the NEM. We are interested in stakeholder views on the materiality of these costs for batteries that are charging from the grid or providing contingency or regulation FCAS. We are also seeking stakeholder feedback on other more incremental potential changes that would support the future provision of consistent and predictable PFR while having a lower impact on the operation of batteries registered as bi-directional units.

The following sections outline these potential solutions.

- Section 3.2.1 describes AEMO's proposal for the mandatory PFR obligations to apply to scheduled bidirectional units when charging.
- Section 3.2.2 describes AEMO's proposal for the mandatory PFR obligations to apply to scheduled bidirectional units when enabled for FCAS.
- Section 3.2.3 describes other more incremental changes to promote the long-term provision of predictable and consistent PFR.

3.2.1 AEMO's proposal for the mandatory PFR obligations to apply to scheduled bidirectional units when charging

AEMO's rule change request proposes to expand the mandatory obligations placed on batteries by requiring scheduled BDUs to operate in PFR mode when charging. Under AEMO's proposal, the revised drafting would be coordinated to apply to BDUs following the commencement of the IESS rule on 3 June 2024.

AEMO's considers that the extension of the mandatory PFR obligation to BDU's while charging is necessary because:

> As the installation of batteries continues in greater numbers and at larger scale, combined with the retirement of large thermal generating unit, their contribution to maintaining good frequency control via the provision of PFR will become increasingly important, and may be insufficient if excluded across significant periods of their operation.

AEMO notes the Commission has not considered in detail the value in requiring batteries to provide PFR when charging. This stems from the Commission's previous position that scheduled loads should be exempt from the mandatory PFR obligations. In response to a proposal from the AEC that the requirements also be applied to scheduled pumps, the Commission concluded that:[41]

> AEMO advised that most scheduled loads, with the exception of battery energy storage systems, are incapable of providing PFR and that the PFRR should not apply to scheduled loads at this time. As such, the Commission has not applied the mandatory PFR rule to Scheduled Loads.

41 AEMC, Mandatory primary frequency response - final determination, pp.148-149.

Given the impending reclassification of batteries as BDUs from 3 June 2024[42], AEMO proposes that the rules be revised to account for the specific capabilities of batteries to provide PFR when charging without affecting other scheduled loads that may not have the same technical capability to provide PFR.

As such, the Commission is seeking stakeholders' views on AEMO's proposal to require batteries to adhere to the PFRR when charging. In particular, the Commission seeks to better understand if such a requirement would result in costs being incurred by battery operators, given the existing proviso that no headroom would need to be retained in order to meet the mandatory obligations.

The remainder of this section outlines AEMO's views on the costs and benefits of this proposed change.

AEMO's expected costs and benefits for the proposal that batteries provide PFR when charging

AEMO considers that the benefits from this proposed rule mirrors the general economic and security justification for making the mandatory PFR and subsequent PFR incentives rules. The request notes that:[43]

> The proposed Rule would positively contribute to the National Electricity Objective (NEO) particularly with respect to promoting efficient investment in, and efficient operation and use of electricity by providing consumers with secure and reliable supply of electricity.

AEMO considers that the proposed changes would be in the long-term interests of consumers as:

- Increasing the available pool of PFR is crucial to ensure adequate control of frequency, thereby promoting power system security as thermal generators are replaced by variable renewable energy. In addition, the change would efficiently promote security by recognising the full spectrum of capabilities scheduled BDUs offer to the power system.
- Ensuring connected plant operate with consistent control settings across running modes allows the system response to contingency events to be better understood and managed, thereby improving system security and reliability.
- The operating costs incurred by plant because of the expanded obligations would be compensated through frequency performance payments.

Recognising the capabilities of batteries to increase the available pool of PFR promotes power system security

In its rule change request AEMO states that expanding the mandatory obligations to scheduled BDUs would enhance system security as batteries would contribute to the control

42 Batteries over 5MW will be reclassified as scheduled bidirectional units, under 5MW as non-scheduled bidirectional units.
43 Ibid., p.19.

base and provide PFR when required. In essence, AEMO's security justification can be summarised as:[44]

> The more resources available to provide mandatory PFR the more secure the power system is for consumers.

Increased security and resilience from improved frequency control has been found to provide benefits to consumers related to the avoidance of costs associated with load interruptions and excess procurement of frequency control services. This underlying assumption was tested in the Panel's *2022 Review of the Frequency operating standard* where GHD analysis confirmed that narrow control of frequency within the PFCB results in:[45]

- lower aggregate frequency control costs for consumers
- improved system resilience to non-credible contingency events.

Consistent frequency settings across operating modes allows the response to contingencies to be better understood and managed

AEMO's rule change proposal seeks to ensure consistent frequency control settings across operating modes. AEMO considers that ensuring scheduled BDUs respond consistently when generating, charging or enabled for market ancillary services provides AEMO with a greater understanding of- and confidence in- the power system's reaction to contingency events, thereby enhancing system security.

AEMO's rule change request explains that:[46]

> If all units operate with the same control settings, set out in the PFRR, the response to contingencies will be better understood, and managed, making the system more secure.

Importantly, AEMO seeks to clarify the mandatory requirements placed on batteries prior to their wide-spread adoption in the NEM:[47]

> Removing the requirements in 4.4.2(c1) that are effectively battery-specific will help ensure that the available control base is maximised as batteries become much more prevalent, and ensure all appropriate plant operates with the same settings in a consistent manner when participating in the market.

Operating costs would be compensated by commercial bids and frequency performance payments

AEMO's rule change request states that extending the mandatory PFR obligations to batteries that are charging or enabled for market ancillary services would not require any additional capital expenditure as they reflect existing capabilities. Nor would scheduled BDUs be required to bear unreimbursed operational expenditure.

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44 Ibid.,
45 Reliability Panel, Review of the frequency operating standard 2022, 7 April 2023, p.X.
46 AEMO rule change request, p.19.
47 Ibid., p.15.

As units would be drawing on plant's existing capabilities, AEMO notes that the extension of the mandatory PFR requirements to scheduled bidirectional units generating would:[48]

> Not require any additional costs for the investment or operation of the services to provide PFR, within the IRP framework established by the IESS rule [as]:
>
> - Existing schedule 5.2.5.11(b)(3) requires that IRPs are to be capable of operating in frequency response mode for both charging and discharging.
> - The proposed Rule is merely extending the obligation to comply with the PFRR and is drawing on this existing capability, rather than requiring enhanced capability from new resources.
> - The operating cost of IRPs providing mandatory PFR, while operating in frequency control mode, are compensated through the frequency performance payments, double-sided incentive regime to be determined by AEMO (as discussed in section 4.1.2) because of the PFR Incentives Rule, and through the IRPs offer price (bids) for regulation and contingency FCAS.

Additionally, AEMO's rule change request states that:[49]

> the operating cost of IRPs providing mandatory PFR, while operating in frequency control mode, are compensated through the frequency performance payments, double-sided incentive regime to be determined by AEMO because of the PFR Incentives Rule, and through the IRPs offer price (bids) for regulation and contingency FCAS.

AEMO's rule change request states that – based on the Commission's previous determinations – the proposed extension of the mandatory PFR obligation to scheduled BDUs supplemented by frequency performance payments should similarly be found to satisfy the NEO and be in the long-term interests of consumers.

AEMO highlighted that in the PFR incentive arrangements final determination, the Commission was:[50]

> satisfied that the confirmation of the mandatory PFR obligation for scheduled and semi-scheduled generators, combined with double-sided incentive arrangements to value helpful active power deviations and new reporting obligations will, or is likely to, contribute to the achievement of the NEO. This will support system security and deliver reduced costs for frequency control over the long term by encouraging innovation and investment in new capability to provide primary frequency response.

The rule change request contends that the proposed change would promote the NEO and align with the efficient investment in- and operation of- batteries by leveraging their full capabilities to support power system security. Importantly, FPPs and energy market offer bids

48 Ibid., p.19
49 Ibid.
50 AEMC, Primary frequency response incentive arrangements - final determination, p.14.

would ensure that the affected BDUs are adequately compensated for the benefits to the system that they provide.

QUESTION 4: ISSUE 2 — STAKEHOLDER VIEWS ON AEMO'S PROPOSAL FOR SCHEDULED BIDIRECTIONAL UNITS TO BE REQUIRED TO PROVIDE PFR WHEN THEY ARE CONSUMING ELECTRICITY FROM THE GRID

- Do stakeholders agree with AEMO's proposal that scheduled bidirectional units should be required to provide PFR when charging?
- Do stakeholders agree with AEMO's assessment of the costs and benefits of the change?
- What are stakeholders views on the cost impacts for batteries providing PFR while charging?

3.2.2 AEMO's proposal for the mandatory PFR obligations to apply to scheduled bidirectional units when enabled for FCAS

AEMO's rule change request proposes to require that scheduled bidirectional units enabled for market ancillary services provide PFR. AEMO's justification closely aligns with the reasoning outlined above with respect to the proposed requirement for scheduled BDUs to provide PFR when charging — outlined in section 3.2.1. AEMO considers that the proposed change is required to provide the necessary and ongoing support for power system security into the future as thermal generators are increasingly replaced by inverter baser resources (IBR) and Distributed Photo-voltaic (DPV) - roof-top solar generation. Under AEMO's proposal, scheduled BDUs would be required to comply with these requirements from the commencement of the IESS rule on 3 June 2024.

AEMO's expected costs and benefits for the proposal that batteries provide PFR when enabled for FCAS

Similarly to the justification outlined in section 3.2.1 above, AEMO considers that the proposal aligns with the general economic and system security logic underpinning the mandatory PFR requirements. AEMO's justification hinges on the view that:

- increasing the supply of PFR is crucial to ensure power system frequency is adequately controlled thereby promoting power system security as thermal generators continue to retire
- leveraging the full suite of capabilities of batteries promotes the efficient use- and operation- of electricity assets
- ensuring connected batteries operate with consistent control settings — irrespective of operating mode — promotes power system security.

Requiring batteries to provide PFR when enabled for FCAS increases the availability of PFR

AEMO's rule change request argues that extending the mandatory PFR requirements to batteries providing FCAS would promote power system security by increasing the availability of PFR to control power system frequency. Under these arrangements, scheduled BDUs

enabled for contingency FCAS would be required to continuously contribute to the maintenance of system security, especially in periods with high DER output.

Leveraging the full capabilities of batteries promotes economic efficiency

AEMO's rule change request states that fully exploiting the multitude of benefits provided by scheduled bidirectional units promotes the system services objective and results in a more efficient use of electricity assets. More efficiently leveraging emerging technologies could result in lower overall costs for consumers.

Consistent control settings across operating modes allows for improved management of contingency events

AEMO's rule change request proposes to require scheduled BDUs to have consistent frequency control settings across operating modes. AEMO contends that this would promote power system security and reliability by supporting consistent and predictable PFR and providing AEMO with a greater understanding of the system's reaction to contingency events. This would support the accurate modelling of the power system response to system disturbances, which is necessary to plan for and implement operational controls to operate the system in a secure operating state, such that it can recover from credible contingency events.

QUESTION 5: ISSUE 2 — STAKEHOLDER VIEWS ON AEMO'S PROPOSAL FOR SCHEDULED BIDIRECTIONAL UNITS TO BE REQUIRED TO PROVIDE PFR WHEN ENABLED TO PROVIDE A MARKET ANCILLARY SERVICE

- What are stakeholders views on AEMO's proposal that scheduled bidirectional units be required to provide PFR when enabled for market ancillary services?
- Do stakeholders agree with AEMO's assessment of the costs and benefits of this change?
- What are stakeholders views on the impacts for a battery in providing PFR while:
  - enabled for regulation services?
  - enabled for contingency services?

3.2.3 Consideration of other more incremental changes to promote the long-term provision of consistent and predictable PFR

In addition to the solutions proposed by AEMO, the Commission will consider whether other more amendments could help address the issue identified in the rule change request and support system security and the long-term provision of PFR. As such, the Commission is interested to consider such measures that would complement the incoming Frequency performance payment arrangements to support the provision of consistent and predictable PFR and address the issues identified by AEMO.

AEMO is currently in the process of developing the procedures and systems to support the implementation of new Frequency performance payment arrangements that will commence from 8 June 2025. These frequency performance payments will value helpful frequency

response provided in accordance with the mandatory PFR requirement and also incentivise the provision of additional PFR — beyond the mandatory requirement — to support the effective control of system frequency into the future.

Based on a preliminary assessment, the Commission has identified a number of potential opportunities to complement the Frequency performance payment arrangements and support the provision of consistent and predictable PFR. These opportunities include consideration of:

- **Registration of voluntary frequency response settings** — Potential processes by which market participants that are not required to provide PFR in accordance with clause 4.4.2(c1) of the NER could voluntarily register their frequency response settings with AEMO . This would enable market participants that are not required to provide PFR to benefit from frequency performance payments.
- **AEMO approval to change a unit frequency response mode** — Review the existing requirement under clause 4.9.4(e) that a generating unit may not change its frequency response mode without prior approval of AEMO. This provision in the NER is intended to support predictable and consistent system frequency response. Given the concerns raised in AEMO's rule change request, and the upcoming changes to NER, it may be timely to reconsider how this element of the NER could best support predictable and consistent frequency response. [51]

Both of these options are explored in greater detail below.

Registration of voluntary frequency response settings

The current mandatory PFR obligations apply to scheduled and semi-scheduled generating units.[52] However, the frequency performance payment arrangements create an incentive framework that applies to a broad range of power system plant, including both scheduled and non-scheduled generation and load. This incentive framework is expected to lead to the long-term and consistent provision of PFR by plant that are not obliged to provide PFR under the mandatory provisions in clause 4.4.2(c1) of the NER.[53]

It is recognised that:

- the frequency performance payments arrangements have the potential to deliver additional voluntary frequency responsive plant
- the registration of voluntary frequency response settings would support predictable and consistent power system frequency response.

Therefore, we are seeking stakeholder feedback on options for the registration of voluntary frequency response settings by eligible plant.

Frequency performance payments could promote the voluntary provision of PFR by non-

51 From 3 June 2024, Clause 4.9.4 (e) of the NER requires scheduled generators or scheduled bidirectional units seek AEMO approval prior to changing frequency control modes.

52 This rule change proposes these to apply to scheduled bidirectional units.

53 The Frequency performance payment arrangements are described in more detail in appendix A.2

scheduled generation and load

As outlined in appendix A, from 8 June 2025 the PFR incentive arrangements rule will introduce frequency performance payments to incentivise the long-term provision of PFR. The registration categories that will be covered by the double-sided frequency performance payment arrangements include:[54]

- a scheduled generating unit,
- a semi-scheduled generating unit,
- a scheduled bidirectional unit
- a scheduled load
- an ancillary service unit
- a non-scheduled generating unit
- a non-scheduled bidirectional unit
- a market connection point for a non-scheduled (customer) load.

The Commission's intent for the frequency performance payments is to value the long-term provision of PFR as the generator fleet becomes increasingly dominated by DPV and variable renewable energy. It is foreseeable that during times of low operational demand, the provision of PFR could increasingly depend on the voluntary provision of PFR from scheduled and non-scheduled loads and other market participants not included in the mandatory obligations.

However, it is also recognised that the level of frequency response provided on a voluntary basis would be uncertain. Therefore, the PFR Incentives rule included requirements for AEMO to report quarterly on aggregate frequency responsiveness in its frequency monitoring reports. This reporting would provide a basis by which to assess the effectiveness of the frequency performance payments at delivering sufficient levels of aggregate frequency response.

Another current rule change being considered by the AEMC also has the potential to complement the new frequency performance payment arrangements and support the provision of voluntary frequency response by new classes of power system plant. The proposed "Light Scheduling unit" registration category could facilitate the integration of non-scheduled price responsive resources into market dispatch. The "light scheduling unit" approach, or similar, would support the provision of information to AEMO that better reflects the way these units respond to the wholesale energy price and improve the accuracy of market dispatch.[55] These new "Light Scheduling Units", or similar, if progressed would be likely candidates for voluntary provision of PFR to supplement the mandatory PFR arrangements.

Another potential opportunity for the provision of voluntary PFR is through the regulatory reforms being considered to support the integration of Virtual power plants into the NEM. The Commission is currently investigating potential changes to the NER that would support

54 *Primary frequency response incentive arrangements Rule 2022*, clause 3.15.6AA(a).

55 See: https://www.aemc.gov.au/rule-changes/scheduled-lite-mechanism

new models of aggregation of responsive consumer energy resources through the flexible trading relationships rule change[56]. This rule change proposes to establish flexible trading arrangements that would enable end users to separate their controllable electrical resources and have them managed independently from their passive load without needing to establish a second connection point to the distribution network. The objective of the reform is to support the transition towards a more active two-sided electricity market and more efficient integration of consumer energy resources (CER) into the electricity system.

The combination of the proposed Scheduled Lite mechanism and the frequency performance payments could unlock additional market participants response to frequency thereby improve control of power system frequency and reducing reliance on scheduled or semi-scheduled generators. Similarly, the Flexible trading arrangements project could promote frequency responsive virtual power plants to benefit from the incentive arrangements.

Registration of voluntary frequency response settings would support predictable and consistent system frequency response

AEMO's objective of consistent and predictable power system frequency response would be supported by the registration of voluntary frequency response settings for relevant plant. Under the frequency performance payment process a non-scheduled market participant would need to install appropriate metering and register their eligible units with AEMO in order to obtain an individual frequency contribution factor for individual frequency performance measurement. This being the case, it could be appropriate for such market participants to be required to also register their frequency response settings with AEMO at the same time.

This proposed approach would align the registration of frequency response settings with unit registration for an individual frequency contribution factor, necessary to benefit from the frequency performance payment arrangements. This approach could provide AEMO with improved visibility of the frequency response settings for power system plant and support consistent and predictable system frequency response following contingency events. It may be in the long-term interests of consumers for units voluntarily benefiting from the incentives to be restricted from unilaterally updating frequency response settings without seeking prior approval from AEMO.

Importantly, the registration of frequency response settings could allow AEMO to compute contribution factors that reflects their individual plant behaviour and forms part of their frequency performance payments.

AEMO approval to change a unit frequency response mode

Clause 4.9.4(e) of the NER states that a scheduled generator (and scheduled bidirectional unit once the IESS rule commences) may not change its frequency response modes without the prior approval of AEMO. Despite dating since the start of the NEM, the clause in question has been somewhat superseded by the requirements for both scheduled and semi-scheduled units to adhere to the requirements in the PFRR when generating.

56 See: https://www.aemc.gov.au/rule-changes/unlocking-CER-benefits-through-flexible-trading

The purpose of the clause is to provide AEMO with confidence in the consistent and predictable response of the power system following contingency events. One question is whether this drafting is still fit for purpose given the obligations on semi-scheduled generators to provide PFR. Revising the obligation could promote consistency and simplicity by revising the clause to reflect the obligations placed on semi-scheduled generators under the mandatory PFR rule.

We are interested in stakeholder feedback on the opportunity to revise this obligation to include other classifications of power system plant that have the capability to be frequency responsive and are of a sufficient scale their response settings could have a material impact on power system security. It may also be appropriate to consider this in the context of the new operational frequency control requirements set out in clause 4.4.2 of the NER.

The drafting of NER cl 4.9.4(e) reflects a historical view that semi-scheduled generator were not able to provide primary frequency response

In 2008, the Commission published the final determination in the *Central Dispatch and Integration of Wind and Other Intermittent Generation* rule that introduced the semi-scheduled classification.[57]

NEMMCO's rule change proposal sought to amend clause 4.9.4(e) to apply the same dispatch-related limitations to semi-scheduled generators as currently apply for scheduled generating units.[58] [59]

Stakeholder submissions questioned the need for the proposed provision on the basis that it would be above and over that agreed in the performance standards. With Auswind noting that:Auswind submission to the Semi-dispatch of Significant Intermittent Generation consultation paper, 10 July 2007, p.30.

- Wind turbines by definition do not have a 'frequency response mode', rather they simply follow the system frequency.
- The provision infers a control function that does not exist.

At the time, the Commission agreed with stakeholder submissions that NEMMCO did not sufficiently justify the need for the requirement that semi-scheduled generators have a frequency response mode facility. As such, the Commission omitted semi-scheduled generators from the requirement to seek AEMO approval prior to updating frequency response modes.[61]

The proposal could promote consistent and predictable PFR

It is now technically feasible for variable renewable generation, including wind and solar, to operate in a frequency response mode, as required by the mandatory primary frequency response obligation. At the same time there is a recognition that the pool of frequency

57 See: https://www.aemc.gov.au/rule-changes/central-dispatch-and-integration-of-wind-and-other
58 NEMMCO, Rule change request - Semi-Dispatch of Significant Intermittent Generation, 23 April 2007, p.49.
59 From 1 July 2009 NEMMCO ceased operations with the roles and responsibilities transferred to AEMO.
61 AEMC, Central dispatch and integration of wind and other intermittent generation - final determination, p.85.

responsive plant will need to expand in order to maintain system security during periods of 100% renewable operation. As such, the Commission is seeking stakeholder feedback on the proposal to require that frequency responsive plant that have registered their frequency response settings with AEMO, may not change these settings, unless by approval of AEMO.

The Commission considers that this these additional or alternative changes could support the consistency and predictability of power system frequency response and help AEMO to plan to maintain the system in a secure operating state, such that it can recover effectively following contingency events.

QUESTION 6: ISSUE 2 — COMMISSION'S OTHER PROPOSED CHANGES TO PROMOTE THE LONG-TERM PROVISION OF PFR

- What are stakeholders views on the Commission's proposed amendments to promote consistent and predictable PFR?
- Are stakeholders aware of any other incremental changes that would help promote consistent and predictable PFR while aligning with the existing mandatory PFR obligation and the incoming Frequency performance payment arrangements?

3.3 Implementation considerations

AEMO's proposed solutions to the issues identified in chapter 2 seek to revise the mandatory PFR obligations on scheduled bidirectional units. As part of the assessment process the Commission will consider any implementation costs incurred by market participants, AEMO and consumers to adhere to any revised requirements. This subsection explores the implementation considerations relating to the:

- proposal to require scheduled BDUs to comply with the PFRR when discharging
- solutions proposed to promote the long-term provision of PFR.

As noted in the rule change request, the implementation process for this rule change proposal would also include updates by AEMO to the PFRR, which sets out the technical requirements for the provision of PFR by eligible units. This process would need to be coordinated with the commencement of the IESS rule from 3 June 2024.

The Commission is seeking stakeholder feedback to guide this process and provide any insights as to how the proposed changes could result in any implementation costs.

3.3.1 Implementation costs related to a mandatory obligation for scheduled bidirectional units to provide PFR obligations when discharging

The Commission considers that implementing the obligation in the rules to ensure batteries remain obligated to provide PFR when discharging is unlikely to result in material costs for market participants, AEMO or consumers.

If AEMO's proposal were adopted by the Commission, AEMO would incur administrative costs by updating the PFRR to reflect the new obligations placed on scheduled bidirectional units.

The compliance costs placed on affected batteries are likely to be insignificant as the changes proposed seek to confirm their existing obligations when operating as scheduled generators.

QUESTION 7: IMPLEMENTATION CONSIDERATIONS OF REQUIRING SCHEDULED BIDIRECTIONAL UNITS TO COMPLY WITH THE PFRR WHEN DISCHARGING

- Do stakeholders consider that there are any further implementation costs that should be considered by the Commission when assessing extending the mandatory PFR obligations to scheduled BDUs while discharging ?

3.3.2 Implementation costs for the proposals to promote the long-term provision of PFR

In this consultation paper, the Commission is seeking stakeholder feedback to gain a better understanding of the estimated implementation and compliance costs to implement the proposed amendments to the second issue.

The Commission understands that adhering to the new requirements would require AEMO to revise the PFRR and would require scheduled BDU operators to update frequency control settings to reflect the expanded requirements. This may require software updates for some operators of bi-directional plant. The Commission is seeking relevant stakeholder insights to allow it to come to the most appropriate decision and quickly resolve any remaining risk and uncertainty for investors and the market.

For the Commission's proposal to investigate the voluntary registration of frequency control settings with AEMO, we are seeking a better understanding of the implementation costs of making plant or equipment sensitive to frequency changes. In addition, the Commission is seeking to test the interest of market participants in to undertake the necessary changes to benefit from frequency performance payments. Stakeholders will provide valuable input in the Commission's assessment of the materiality of the issue and the effectiveness of the proposed changes.

QUESTION 8: IMPLEMENTATION CONSIDERATIONS OF SOLUTIONS TO PROMOTE THE LONG-TERM PROVISION OF PFR

- What are stakeholders' views on the implementation considerations identified for BDU's to be required to provide PFR while charging and providing FCAS?
- What are stakeholders' views on the implementation considerations for the other incremental changes identified by the Commission to support predictable and consistent provision of PFR?

4 MAKING OUR DECISION

When considering a rule change proposal, the Commission considers a range of factors.

This chapter outlines:

- issues the Commission must take into account
- the proposed assessment framework
- decisions the Commission can make.

We would like your feedback on the proposed assessment framework.

4.1 The Commission must act in the long-term interests of consumers

The Commission is bound by the National Electricity Law (NEL) to 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.

Currently, the NEO is:

> BOX 1: THE NEO
>
> To promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers of electricity with respect to:
>
> - price, quality, safety, reliability, and security of supply of electricity; and
> - the reliability, safety, and security of the national electricity system.

In coming to its decision in relation to whether the proposed rule will contribute to the NEO, the Commission will consider both the system services objective and a set of assessment principles for this rule change process, described below.

4.1.1 Considering the emissions reduction objective

In May 2023, Energy Ministers approved amendments to the national energy laws to implement their previous decision to incorporate an emissions reduction objective into the NEO, National Energy Retail Objective, and National Gas Objective.[62]

The legislative process to introduce an emissions reduction objective into the national energy objectives is currently in train, and is expected to be completed in September 2023.[63] Although the emissions reduction objective is not yet in effect, it is likely to be in effect by the time the Commission makes its draft determination for this rule change. We seek stakeholder feedback on how the proposed rule would contribute to the new NEO.

62 Department of climate change, energy and environment and water, 2023. Energy and climate change ministerial council meeting communique, 19 May 2023.

63 The Statutes Amendment (National Energy Laws) (Emissions Reduction Objectives) Bill 2023 was introduced into South Australian Parliament on 14 June 2023.

When the new NEO takes effect, the Commission will be guided by the new NEO in its assessment of AEMO's rule change request, as discussed below.

4.2 The system services objective for considering issues related to system services

The system services objective has been developed by the Commission to assess whether system services rule changes contribute to the NEO.

It reflects the trade-offs that are expected when considering issues related to the provision of system services. The system services objective seeks to:

BOX 2: THE SYSTEM SERVICES OBJECTIVE

Establish arrangements to optimise the reliable, secure and safe provision of energy in the NEM, such that is it provided at efficient cost to consumers over the long-term, where 'efficient cost' implies the arrangements must promote efficient:

- short-run operation of
- short-run use of,
- longer-term investment in, generation facilities, load, storage, networks (i.e. the power system) and other system service capability.

Efficient short-run operation refers to factors associated with the ability of the service design option to achieve an optimal combination of inputs to produce the demanded level of the service at least cost i.e. for a given level of output, the value of those resources (inputs) for this output are minimised.

Efficient short-run use refers to factors associated with the ability of a service design option to allocate limited resources to deliver a service, or the right combination of services, according to consumer preferences or system need.

Efficient longer-term investment refers to factors associated with the ability of the service design option to continue to achieve allocative and productive efficiencies over time. This means developing flexible market and regulatory frameworks, that can adapt to future changes.

Achieving dynamically efficient outcomes, given these attributes, will require flexible regulatory frameworks.

4.3 We propose to assess the rule change using these five criteria

Our regulatory impact analysis methodology

Considering the NEO and the issues raised in the rule change request, the Commission proposes to assess this rule change request against the set of criteria outlined below, in addition to the system services objective (above). These assessment criteria reflect the key

potential impacts – costs and benefits – of the rule change request. We consider these impacts within the framework of the NEO.

The Commission's regulatory impact analysis may use qualitative and/or quantitative methodologies. The depth of analysis will be commensurate with the potential impacts of the proposed rule change. We may refine the regulatory impact analysis methodology as this rule change progresses, including in response to stakeholder submissions.

Consistent with good regulatory practice, we also assess other viable policy options – including not making the proposed rule and making a more preferable rule – using the same set of assessment criteria and impact analysis methodology where feasible.

Assessment criteria and rationale

The proposed assessment criteria and rationale for each is as follows:

1. **Safety, security and reliability** – 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 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. 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.
2. **Emission reductions** – the market and regulatory arrangements for frequency control should efficiently contribute to the achievement of government targets for reducing Australia's greenhouse gas emissions. (Note that we will apply this criterion if and when the law changes to include emission reduction targets in the NEO take effect.)
3. **Principles of market efficiency** – 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.
4. **Innovation and 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, 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.

5. **Principles of good regulatory practice** – 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.

QUESTION 9: ASSESSMENT FRAMEWORK

- Do you agree with the proposed assessment criteria?
- Are there additional criteria that the Commission should consider or criteria included here that are not relevant?

4.4 We have three options when making our decision

After using the assessment framework to consider the rule change request, the Commission may decide:

- to make the rule as proposed by the proponent[64]
- to make a rule that is different to the proposed rule (a more preferable rule), as discussed below, or
- not to make a rule.

The Commission may make a more preferable rule (which may be materially different to the proposed rule) if it is satisfied that, having regard to the issue or issues raised in the rule change request, the more preferable rule is likely to better contribute to the achievement of the NEO.[65]

4.5 The proposed rule would not apply in the Northern Territory

Parts of the NER, as amended from time to time, apply in the Northern Territory, subject to modifications set out in regulations made under the Northern Territory legislation adopting the NEL.[66]

The proposed rule would not apply in the Northern Territory, as it amends provisions in NER chapter 4 and schedule 5 that do not apply in the Northern Territory.[67] Consequently, the Commission will not assess the proposed rule against additional elements required by the Northern Territory legislation.

64 The proponent sets out its proposed rule in pp. 22-25.

65 Section 91A of the NEL.

66 National Electricity (Northern Territory) (National Uniform Legislation) Act 2015 (**NT Act**). The regulations under the NT Act are the National Electricity (Northern Territory) (National Uniform Legislation) (Modification) Regulations 2016.

67 Under the NT Act and its regulations, only certain parts of the NER have been adopted in the Northern Territory. The version of the NER that applies in the Northern Territory is available on the AEMC website at: https://energy-rules.aemc.gov.au/ntner.

A PREVIOUS RELATED RULE CHANGES AND FREQUENCY PERFORMANCE PAYMENTS

This project builds on previous work completed by the Commission and the Reliability Panel to establish enduring frameworks for the provision of PFR. This appendix provides an overview of the relevant projects, including:

- Appendix A.1 — the *Mandatory primary frequency response rule 2020*
- Appendix A.2 — the *Primary frequency response incentive arrangements rule 2022*
- Appendix A.3 — the *Integrating energy storage systems in the NEM rule 2021*
- Appendix A.4 — the Reliability Panel's 2022 *Review of the frequency operating standard*.

A.1 The mandatory PFR rule introduced obligations for scheduled and semi-scheduled generators to provide narrow-band PFR

In March 2020 the Commission made a rule introducing an obligation for all scheduled and semi-scheduled generators in the NEM to provide PFR by responding automatically to small changes in power system frequency (the Mandatory PFR rule). The final determination responded to rule change requests from AEMO and Dr Sokolowski that called for the introduction of mandatory obligations for provision of PFR by scheduled and semi-scheduled generators in the NEM. The proponents expressed the view that the absence of a PFR requirement in the NER contributed to a degradation in frequency control over the period 2014 to 2018 and that this compromised the security and resilience of the power system. AEMO's rule change request was informed by the findings from its investigation of the power system separation event that occurred on 25 August 2018 and expert advice provided by Dr John Undrill.

The Commission's decision was supported by expert technical advice from AEMO and independent advice from GHD as well as submissions by power system engineers, transmission networks and Hydro Tasmania. However, many stakeholders expressed concern that the mandatory PFR was unlikely to be the most efficient option for valuing primary frequency response in the long-term. These stakeholders reasoned that incentives or market-based arrangements to provide PFR would likely be more efficient and effective over the longer term.

At the time of making the Mandatory PFR rule, the Commission acknowledged that mandatory PFR on its own was not a complete solution and was not sufficient to deliver effective economic signals to meet the operational needs of the power system now and into the future. To reflect the interim nature of the mandatory arrangement on its own, the final rule included provisions for the mandatory PFR requirement to sunset after three years on 4 June 2023.

Further details are available in the mandatory PFR final determination available on the AEMC website.[68]

A.2 PFR Incentive arrangements rule introduced frequency performance payments to complement the mandatory requirement

On 8 September 2022, building on previous reforms, the Commission made a final determination establishing an enduring framework for the control of power system frequency. The core elements of the final rule were:

- **Confirmation that the mandatory primary frequency response (PFR) arrangements would endure beyond 4 June 2023**. This meant that all scheduled and semi-scheduled generators would continue to be required to support the secure operation of the power system by responding automatically to changes in power system frequency.
- **The introduction of a new double-sided frequency performance payments process to encourage plant behaviour that helps to control power system frequency**. The Commission's view was that these arrangements, commencing on 8 June 2025, would value and reward helpful frequency response from plants provided in accordance with the mandatory PFR requirement and would also incentivise the provision of additional PFR to support the effective control of system frequency into the future. This would align economic incentives for plant active power performance with behaviour desirable for controlling power system frequency.
- **New reporting obligations for AEMO and the AER in relation to the levels of aggregate frequency responsiveness in the power system and the costs of frequency performance payments**. The Commission considered that this change supported the principle of transparency and would provide relevant information to market participants and stakeholders to assess the effectiveness and efficiency of the frequency control frameworks over time.

The Commission's view remains that the mandatory PFR requirements, combined with the frequency performance payments, provide an enduring framework by which the long-term security of the power system can be maintained.

The double-sided frequency performance payments process is built on the existing 'causer pays' arrangements for regulation FCAS to incentivise plant behaviour that provides PFR to the system. Payments will be made to market participants who help control and reduce frequency deviations from 50 Hz, for which the costs will be allocated to market participants who contribute to the frequency deviations. The degree of payments and costs will depend on each plant's contributions to control frequency in each trading interval. Box 3 below provides additional information on the frequency performance payments process that will commence on 8 June 2025.

68 *See: https://www.aemc.gov.au/rule-changes/mandatory-primary-frequency-response*

BOX 3: FREQUENCY PERFORMANCE PAYMENTS

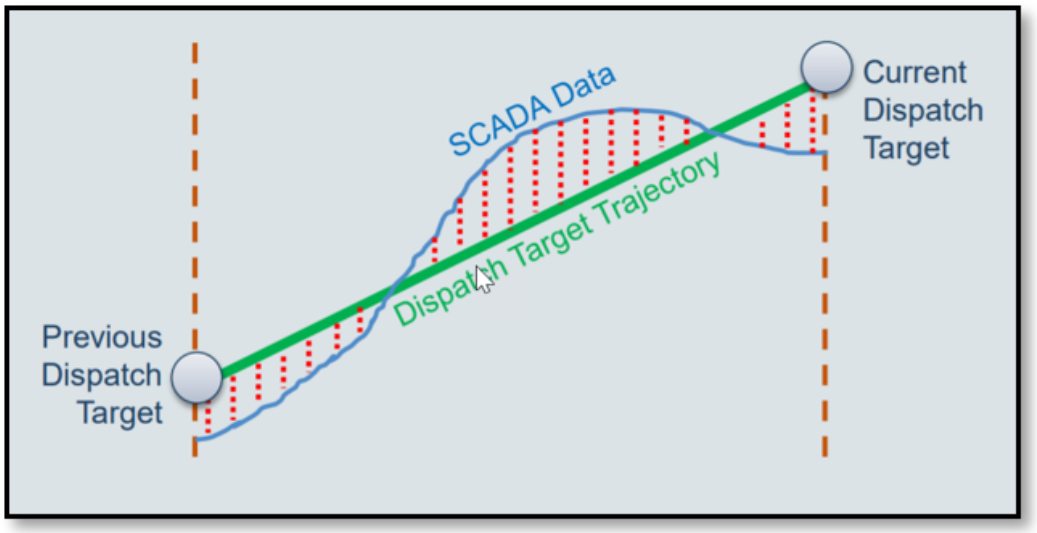
The key reform in the PFR incentive arrangements rule is the introduction of a double-sided frequency performance payments process, commencing on 8 June 2025, for all eligible units of generation and load:

- a scheduled generating unit,
- a semi-scheduled generating unit,
- a scheduled bidirectional unit,
- a scheduled load,
- an ancillary service unit,
- a non-scheduled generating unit,
- a non-scheduled bidirectional unit, or
- a market connection point for a non-scheduled (customer) load.

The new process was designed to deliver improved valuation and pricing of plant behaviour that impacts on power system frequency by building on existing 'causer pays' arrangements for the allocation of regulation FCAS costs.

The frequency performance payments are determined for each unit, with different calculation methods for if the unit has appropriate metering or not. Appropriate metering means that a unit's power deviations can be measured from SCADA data, updated every 4 seconds in the mainland, to determine each unit's individual contribution to frequency deviations. A general example of measurements of unit power deviations is presented in Figure A.1.

Figure A.1: Power deviation measurement of a unit with appropriate metering



Source: AEMO, Regulation FCAS contribution factor procedure – Determination of contribution factors for regulation FCAS cost recovery, 9 November 2018, p.12.

Units with appropriate metering have individual contribution factors

For units with appropriate metering, the frequency performance payments for each unit in each trading interval are calculated by:

$$FPP = CF \; x \; \frac{Price_{regulation}}{12} \; x \; RCR$$

where:

FPP	- the frequency performance payment (in $) to be paid (for a negative contribution factor) or received (for a positive contribution factor) by the eligible unit;
CF	- the individual contribution factor (a number between -1 and 1) determined by AEMO for the eligible unit, where a positive value corresponds to reducing frequency deviations and a negative value corresponds to contributing to frequency deviations;
$Price_{regulation}$	- the spot price (in $/MW/hr) of the regulating raise service or regulating lower service in that trading interval, as regulation FCAS prices provide a fair valuation for providing PFR;
12	- the factor to divide the regulation price (in $/MW/hr) to give a price in $/MW for each five minute trading interval;
RCR	- the requirement for corrective response (in MW) determined by AEMO corresponding to the 'volume' of PFR required to correct frequency deviations.

Units without appropriate metering have a residual contribution factor

For units without appropriate metering, the individual contribution factor is replaced with a residual contribution factor based the aggregate performance of all non-metered units. Individual payments and costs are then scaled depending on the energy consumed or generated by each non-metered unit relative to the gross aggregate energy from non-metered units.

Further details are available in the PFR incentive arrangements final determination available on the AEMC website.[69]

A.3 The integrating energy storage system rule introduced the bidirectional unit as a new category of market participant

On 2 December 2021, the Commission made a final determination to make it easier for energy storage systems and hybrid facilities to register and participate in the national electricity market. The final rule aimed to facilitate the future market where storage and

69 See: https://www.aemc.gov.au/rule-changes/primary-frequency-response-incentive-arrangements

hybrid systems are likely to play a much bigger role in firming renewable energy while ageing generators continue to transition out of the market.

The core elements of the final rule, to better integrate energy storage into the NEM, were:

- A new registration category, the Integrated Resource Provider (IRP), that allows storage and hybrids to register and participate in a single registration category rather than under two different categories.
- Clarity for the scheduling obligations that apply to different configurations of hybrid systems, including DC-coupled systems, so that operators of these systems have the flexibility to choose whether to be scheduled or semi-scheduled.
- Allowing hybrid systems to manage their own energy behind the connection point, subject to system security limitations.
- Clarifying that the current approach to performance standards that are set and measured at the connection point will apply to grid-scale storage units, including when part of a hybrid system.
- Transferring existing small generation aggregators to the new category, and enabling new aggregators of small generating units and/or storage units to register in this category. Aggregators registered in the IRP category will be able to provide market ancillary services from generation and load.
- Amending the framework to recover non-energy costs based on a participant's consumed and sent out energy over relevant intervals, irrespective of the participant category.

The Commission's final determination to introduce the new registration category — the IRP — sought to accommodate a variety of participants with bidirectional energy flows that may offer and consume energy and ancillary services. This included grid-scale storage, hybrids and aggregators of small generation and storage units. Once the majority of the changes made by the final rule come into effect on 3 June 2024, IRPs will be required to classify standalone storage:

- 5MW and above as a scheduled bidirectional unit, and
- under 5MW as a non-scheduled bidirectional unit.

In the short-term, the final decision removed barriers to storage and hybrid systems participating in the market by introducing a new technology neutral participant category to accommodate participants with bidirectional energy flows.

In the longer term, these changes:

- removed barriers to entry for more flexible resources and services in the future power system, including providing flexibility to accommodate new forms of participants such as small and large storage units embedded into hybrid systems as well as standalone units
- facilitated innovative business models that deliver efficient market solutions to address the needs of the transitioning system
- provided a market signal to investors that the new category is being set up as the future universal category outlined in the ESB's post-2025 work

- were the first steps along the path towards a two-sided market in the NEM where technical obligations are placed on services not participant categories.

Further details are available in the IESS final determination on the AEMC website.[70]

A.4 The 2022 Reliability Panel review of the Frequency operating standard confirmed the important role of widespread narrow band PFR in supporting system security, resilience and economic efficiency

On 6 April 2023, the Panel published its final determination revising the FOS to adapt to the changing nature of the power system as thermal generators are replaced by inverter-based resources. The revised FOS, which will commence on 9 October 2023, specifies the expected frequency outcomes for the electricity system in the NEM and sought to promote the national electricity objective (NEO) by managing the trade-off between the benefits of a secure and resilient power system and the costs of achieving this, in so promoting the long-term interests of consumers.

The core elements of the revised FOS were:

- the introduction of system limits for rate of change of frequency (RoCoF) following contingency events
- changes to the settings that relate to the limits and thresholds for contingency events
- changes to the FOS that applies during system restoration following a major system disturbance
- confirmation of the allowable ranges for frequency during normal operation, the primary frequency control band (PFCB) and that the target frequency is 50 Hz
- the removal of the limit for accumulated time error.

The confirmation of the settings for normal operation, including the PFCB, was supported by technical advice from AEMO and the results of extensive power system modelling undertaken by GHD. The analysis showed that the PFCB drives the frequency distribution around 50 Hz and the provision of narrow-band PFR by the bulk of the generation fleet delivers:

- Effective control of power system frequency – the GHD analysis showed the PFCB is crucial to maintaining a narrow distribution of frequency around 50 Hz, which combined with AEMO's advice that effective control of frequency is fundamental to power system security, implies that narrow-band PFR promotes system security.
- Increased power system resilience – the GHD analysis showed narrow-band PFR delivers improved system resilience by reducing the risk and volume of load shedding following non-credible contingency events, increasing the likelihood of rapid resynchronisation following a separation event and providing effective redundancy in the event of a failure of the centralised control and communication systems (SCADA).

70 *See: https://www.aemc.gov.au/rule-changes/integrating-energy-storage-systems-nem*

- Reduced aggregate costs for frequency control – the GHD analysis predicts that narrower PFCB settings would deliver lower total costs for control of power system frequency. The expected reduction in costs accounts for the costs of both PFR and regulation FCAS which work together to ensure adequate control of power system frequency during normal operation.

The Panel recommended that a subsequent review of the FOS be completed no later than the end of 2027 to reconsider the settings in the FOS for normal operation taking into account the market and system impacts stemming from the commencement of the frequency performance payment arrangements in 2025.

Further details are available in the Reliability Panel's 2022 review of the frequency operating standard final determination on the AEMC website.[71]

71 *See: https://www.aemc.gov.au/market-reviews-advice/review-frequency-operating-standard-2022*

B THE COSTS AND BENEFITS OF WIDESPREAD PFR

The provision of primary frequency response (described in Box 4 below) has many benefits for frequency control, both during normal operation and following contingency events. However, the Commission also acknowledges that costs are incurred by generators and bidirectional in providing this service.

BOX 4: 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."

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.

Contingency FCAS is a form of PFR, in that it is fast-acting, automatic local response to frequency disturbance. However, contingency FCAS is designed to provide a sporadic response to rebalance supply and demand following occasional contingency events. AEMO identified that it is the aggregate frequency responsiveness provided by a broad base of frequency responsive plant that is required to provide effective frequency control. High levels of aggregate frequency responsiveness have been shown to deliver improved control of system frequency, increased system resilience and an overall reduction in the total cost of system operation.

Source: AEMC, Mandatory primary frequency response - final determination, 26 March 2020, p.4.

Historically in the NEM, only synchronous generating systems have provided PFR. However, inverter-based generators such as wind, batteries and solar PV, can also provide PFR.

As these technologies have started to form an increasingly large proportion of the supply mix, the mandatory PFR obligations require any scheduled or semi-scheduled generator to operate in frequency response mode when generating. As identified in AEMO's *Engineering Framework,* the reliable provision of PFR by inverter-based resources is crucial to enable the system secure operation at 100% instantaneous penetration of renewable.[72]

As outlined in section 1.2, the costs and benefits from the provision of widespread narrow-band PFR have been thoroughly investigated by the Commission and Reliability Panel. Both the PFR incentive arrangements rule and 2022 review of the frequency operating standard projects supported the continuation of the current mandatory arrangements as a prudent solution to maintain satisfactory frequency control and thereby promote power system security. A summary of the costs and benefits is detailed below.

B.1 The costs of providing PFR

The Commission recognises that there are costs incurred due to the provision of primary frequency response. These costs include upfront capital costs associated with setting up power system plant with the capability to be frequency responsive and ongoing operating costs related to provision of PFR. Further, it is acknowledged that these costs vary depending on each individual plant technology and operational conditions. The ongoing costs could include:

- direct utilisation costs of providing the response through increased wear and tear and resource consumption
- opportunity costs of foregoing alternative revenue through the energy market.

B.1.1 Units providing PFR incur increased maintenance costs and increase resource consumption

The Commission's introduction of the mandatory requirement sought to minimise the ongoing maintenance and fuel costs for individual generators by ensuring a broad base of generators are responsive to frequency. The broad compliance base ensures that no single generator is unduly burdened by being required to provide a disproportionate amount of PFR.

Stakeholder submissions to the mandatory PFR draft determination identified that units complying with the PFRR would incur greater utilisation costs through:

- Increased wear and tear resulting in diminished fuel efficiency over time or increased cycling costs for batteries.
- The cost of movement, which for thermal generators, requires generating additional steam pressure to allow for ramping to dispatch targets. Over time the higher boiler pressure increases operating costs by reducing energy efficiency.

For cases in which the operating cost of requiring a generator to comply with the PFRR may be challenging to absorb or could jeopardise the commercial viability of the business the

72 AEMO, Engineering Roadmap to 100% Renewables, December 2022.

Commission included the power for AEMO to grant case-by-case exemptions or derogation from the technical requirements. For example, the Commission notes AEMO has agreed to generator specific settings for Crowlands WF, Moorabol WF, Poatine PS and Vales Point PS.[73]

The exemption principles seek improve transparency and avoid excessive and unjustifiable compliance or operating costs for eligible plant while still delivering on system security and frequency control objectives.

B.1.2 Units providing PFR incur the opportunity cost of foregoing revenue through the energy market

In the mandatory PFR final determination, the Commission clearly specified that the PFRR cannot require generators to maintain additional headroom or stored energy for the purposes of providing primary frequency response. Any such obligation could impose substantial costs on generators that would likely far out-weigh the additional benefits this might provide to the security of the power system.

However, stakeholder submissions previously identified that the obligations to provide PFR — even without being required to maintain headroom — could still result in forgone revenue. For thermal generators, fuel efficiency could be compromised due to the increased stored energy requirements to provide PFR. For semi-scheduled generators, as they typically operate at full output with no headroom, they will likely only provide lower PFR resulting in lost energy revenue.

B.2 Widespread narrow-band PFR supports power system security and resilience

AEMO's advice is that widespread narrow band PFR is necessary to maintain effective control of frequency, which is fundamental to a secure and resilient power system.[74]

Analysis undertaken for the Panel by GHD provided further evidence that widespread narrow band PFR is expected to support a secure and resilient power system. This increase in system resilience was demonstrated through expectations for reduced load shedding following significant non-credible contingency events, and a significant increase in the likelihood of resynchronisation for islanded regions following such separation events.[75]

As outlined below, the mandatory PFR arrangements have been shown to:

- lead to restoration of tight frequency control around the NOFB
- improve system resilience by reducing post-contingency recovery times
- reduce the number of NOFB exceedances.

AEMO's rule change request also identified that mandatory PFR obligations improve their ability to model and predict power system behaviour by providing increased certainty around

73 AEMO, Implementation of the National Electricity Amendment (Mandatory Primary Frequency Response) Rule 2020 status report,17 November 2022, pp.9-22.

74 AEMO, Enduring primary frequency response requirements for the NEM, August 2021, pp.22-25.

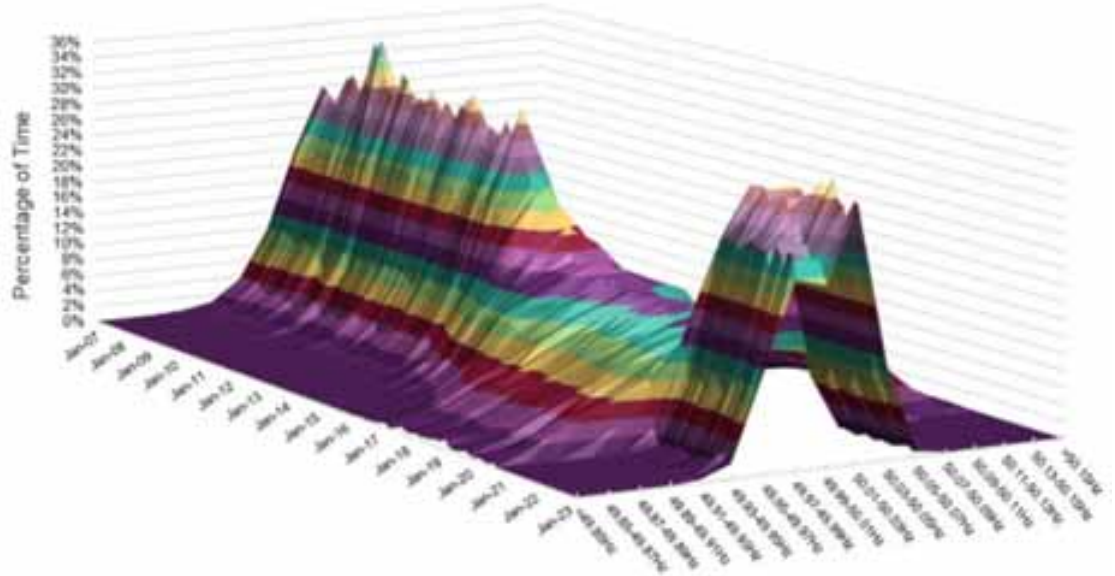
75 GHD, Advice for the 2022 Frequency Operating Standard review - Power system and economic impacts due to variation of the PFCB, 21 November 2022, p.13.

how generation plant will behave following power system disturbances. This supports the accurate modelling of the power system to simulate and confirm power system security following potential contingency events.[76]

B.2.1 Mandatory PFR led to a restoration of tight frequency control around the NOFB

The introduction of the mandatory obligations in 2020 led to a restoration of tight frequency control around the normal operating frequency band (NOFB) – illustrated in Figure B.1 below – due to the coordinated reinstatement of narrow deadbands by a majority of the generation fleet.

Figure B.1: Monthly mainland frequency distribution



Source: AEMO, Frequency and Time Error Monitoring report - Q1 2023, May 2023, p.10.

B.2.2 Mandatory PFR has improved system resilience by reducing post-contingency frequency recovery times

The introduction of mandatory PFR has improved resilience in the power system and reduced the impact of contingency events on power system frequency. Average recovery times of frequency to return within the NOFB following large generation events have reduced by about 90% and average frequency nadirs following large generation and load events have moved closer to 50 Hz.[77]

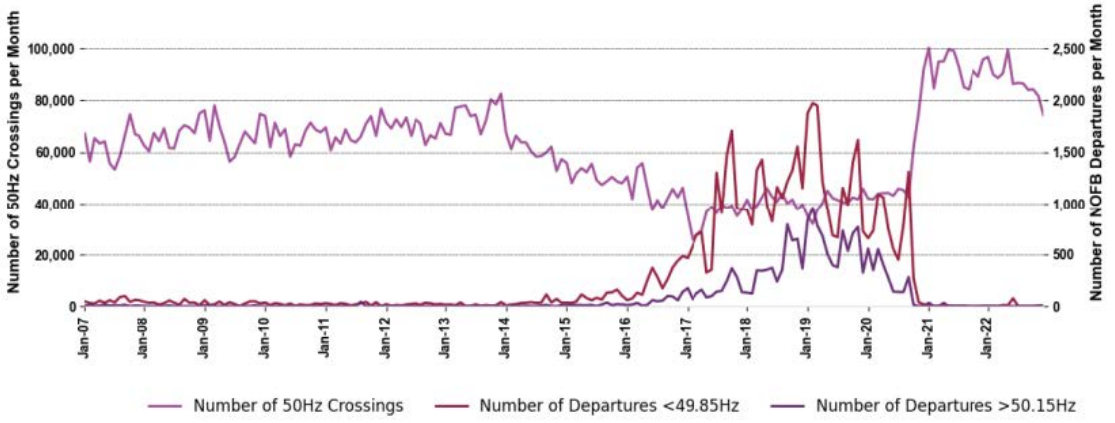
76 AEMO, Mandatory primary frequency response — Electricity rule change proposal, 16 August 2019, p.25.

77 AEMO, Frequency and Time Error Monitoring — Quarter 4 2022, February 2023, p.19.

B.2.3 Mandatory PFR has reduced the number of NOFB exceedances

The number of departures from the NOFB have fallen dramatically and the number of times frequency crossed 50 Hz has increased, corresponding with the tightening of the frequency distribution around 50 Hz.[78] These improvements in frequency performance are illustrated clearly in Figure B.2 and demonstrate a strong system-wide response to frequency deviations following the implementation of mandatory PFR.

Figure B.2: Monthly mainland frequency NOFB and 50Hz crossings



Source: AEMO, Frequency and Time Error Monitoring - Quarter 4 2022, February 2023, p.9.

There have been no exceedances of the FOS in the mainland since the implementation of mandatory PFR in late 2020.[79] This demonstrates the effectiveness of mandatory PFR at improving AEMO's ability to maintain frequency control.

B.3 Widespread narrow-band PFR delivers lower aggregate frequency control costs

A key focus of the Reliability Panel's 2022 review of the frequency operating standard was an analysis of the costs and benefits associated with different settings for the PFCB and system performance during normal operation.[80] The Panel's final determination found:[81]

> [The settings for normal operation] element of the Panel's determination is supported by advice from AEMO and the results of power system modelling undertaken by GHD which shows that provision of narrow band PFR by the bulk of the generation fleet delivers effective control of system frequency, increased power system resilience and reduced aggregate costs for frequency control.

78 Ibid., p.9.

79 Note: There are numerous FOS exceedances in Tasmania when the Basslink interconnector is either at its import limit or out of service; this frequency performance is expected due to operational characteristics.

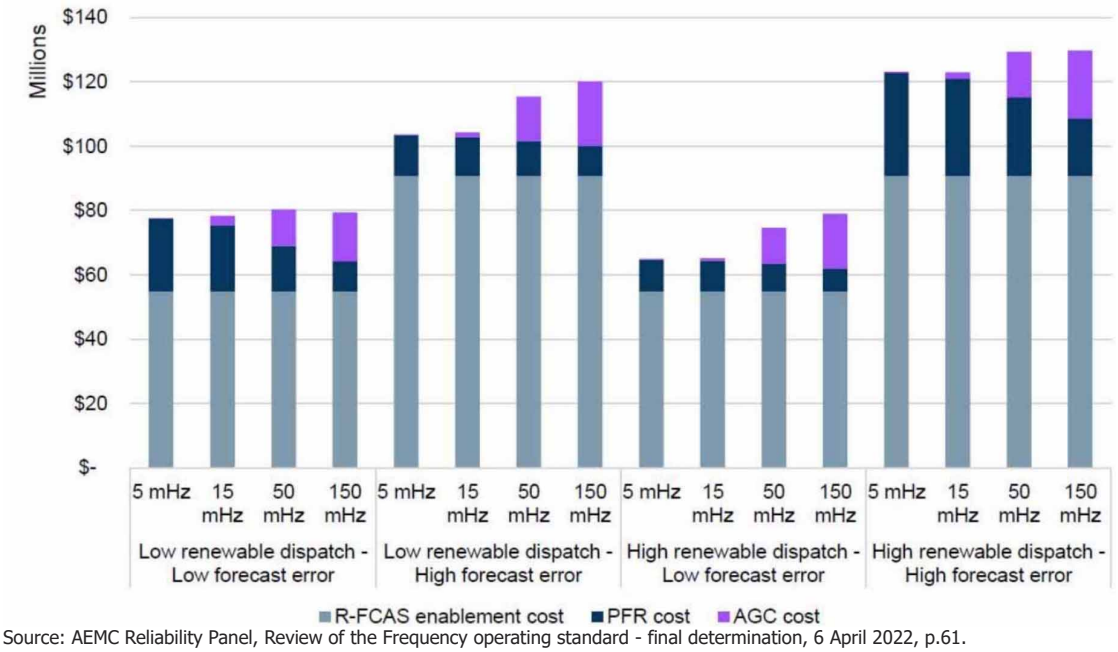
80 The primary frequency control band sets the lower bound for the maximum allowable deadband that AEMO specifies for affected generators in its PFRR. The PFCB is currently set as 49.985 – 50.015 Hz following the Reliability Panel's review of the FOS.

81 Add reference

The GHD analysis showed that narrower PFCB settings would deliver lower total costs for control of power system frequency. The expected reduction in costs with narrower PFCB settings account for the costs of both PFR and regulation FCAS which work together to maintain adequate control over power system frequency during normal operation.

As outlined in Figure B.3 below the modelling predicted reduced PFR costs and duty with wider deadbands, however the reduction was more than offset by increased regulation FCAS costs. This analysis, combined with the security and resilience benefits, played a key role in the Panel's determination to retain the existing settings for normal operation.

Figure B.3: Aggregate frequency control costs for different PFCB settings - annualised

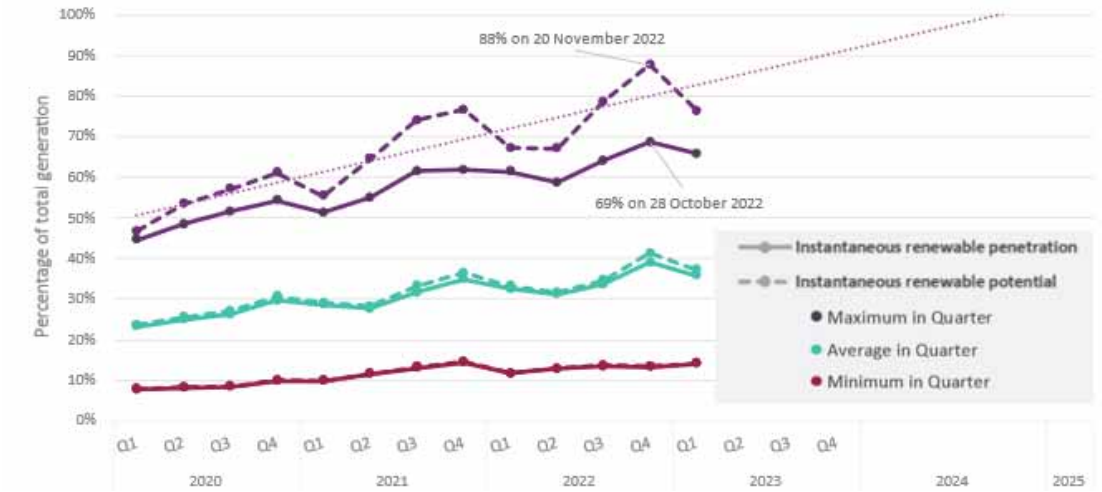


Source: AEMC Reliability Panel, Review of the Frequency operating standard - final determination, 6 April 2022, p.61.

B.4 Reliable provision of PFR is required to operate the network at 100% instantaneous IBR

In the *Engineering Framework* AEMO is investigating and defining the operational, technical and engineering requirements needed to meet system needs in the NEM over the next five to ten years. The objective of the framework is to facilitate the orderly transition to a secure and efficient future NEM system. Figure B.4 below illustrates AEMO projection that there will be enough renewable resource potential to reach 100% of grid demand, for a small number of dispatch periods, as early as 2025.

Figure B.4: NEM quarterly instantaneous renewable penetration and resource potential



Source: AEMO, Engineering Roadmap to 100% Renewables | FY2024 Priority Actions, 10 July 2023, p.8

In December 2022, AEMO published the *Engineering Roadmap to 100% renewables* that sought to provide stakeholders with an overview of the engineering challenges and associated actions that will need to be undertaken to operate the NEM for the first period of 100% renewable penetration and an indication of the actions required to satisfy regular operation at 100% renewable penetration. As a pre-condition for the first 100% renewable period, AEMO identified that the:[82]

> Reduction in available frequency response due to VRE and distributed photovoltaics (DPV) displacing synchronous fossil fuel generation online could result in challenges in maintaining sufficient narrow-band primary frequency response, regulation and contingency frequency control in the power system, since DPV does not currently supply these services.

AEMO's has in the meantime conducted a feasibility study which indicated that, in absence of further action, the NEM could be at risk of poorer frequency control during times of high DPV.[83] In seeking to address the identified gap and enable operation of the network at 100% renewables, AEMO is seeking action to:[84]

> Implement measures to ensure sufficient aggregate frequency response and regulation FCAS is online during high DER periods [which] may require mechanisms to manage headroom from large scale VRE and storage and narrow-band PFR from DER devices

82 AEMO, Engineering Roadmap to 100% Renewables, December 2022, pp. 30-31.
83 AEMO, Engineering Roadmap to 100% Renewables | FY2024 Priority Actions, 10 July 2023, p.28.
84 AEMO, Engineering Roadmap to 100% Renewables, December 2022, p.74.

In addition, AEMO is continuing to work with OEMs to ensure adherence by scheduled and semi-scheduled generator to the mandatory PFR obligations and progress on implementing the frequency performance payments to incentive improved plant behaviour.[85]

AEMO's view is that the preparation for the first dispatch interval at 100% renewable operation needs to occur ahead of the last fossil fuel generating unit decommitting. Changing operating practices by thermal plant — such as decommitting for the middle of the day or for longer periods — means that this could happen well in advance of the eventual retirement of all these units.[86]

85 Ibid.
86 Ibid., p.14.

ABBREVIATIONS

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AGC	Automatic generation control system
CF	Contribution factor
CER	Consumer energy resource
Commission	See AEMC
DER	Distributed energy resource
DPV	Distributed photovoltaics
ESB	Energy Security Board
ESS	Essential system services
FCAS	Frequency control ancillary service
FFR	Fast frequency response
FOS	Frequency operating standard
FPP	Frequency performance payment
GW	Gigawatt
IBR	Inverter-based resources
MASS	Market ancillary service specification
MW	Megawatt
NEL	National Electricity Law
NEM	National Electricity Market
NEO	National Electricity Objective
NER	National Electricity Rules
NOFB	Normal operating frequency band
NER	National Electricity Rules
PFCB	Primary frequency control band
PFR	Primary frequency response
PFRR	Primary frequency response requirements
RCR	Requirement for corrective response
RoCoF	Rate of change of frequency
TNSP	Transmission network service provider
VPP	Virtual power plant
VRE	Variable renewable energy (generation)