



Primary Frequency Response Requirements

Draft Report – Standard consultation for the National Electricity Market

Published: 20 February 2023

aemo.com.au

New South Wales | Queensland | South Australia | Victoria | Australian Capital Territory | Tasmania | Western Australia
Australian Energy Market Operator Ltd ABN 94 072 010 327

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Executive summary and consultation notice

The publication of this draft report commences the second stage of the standard consultation procedure conducted by AEMO to amend the Primary Frequency Response Requirements (**PFRR**) under the National Electricity Rules (**NER**) (the **proposal**).

This consultation is undertaken as required by NER 11.152.2, following the procedure in NER 8.9.2. It follows the Australian Energy Market Commission's (**AEMC**'s) determination in September 2022 of the National Electricity Amendment (Primary frequency response incentive arrangements) Rule 2022 (**PFR incentives rule**), which continued the mandatory primary frequency response (**PFR**) obligations in the NER¹. The current interim PFRR will therefore be replaced by an enduring PFRR at the conclusion of this consultation, addressing the requirements in NER 4.4.2A.

AEMO received four submissions in the first stage of its consultation on the proposal, with feedback on aspects of all issues noted in the consultation paper other than the proposal to remove the PFR transitional provisions.

Based on the feedback received and further review, AEMO has made material changes to the draft PFRR to address the following matters:

- Confirmation that provision of PFR is only mandatory in the circumstances specified in the NER (that is, when in receipt of a dispatch instruction to generate energy), noting only that AEMO's preference (from a power system operations perspective) is for continuous response.
- Expressly adding that headroom and footroom do not need to be maintained for PFR purposes.
- Confirmation that the application of a narrower PFR deadband is subject to AEMO approval, as are changes to any settings of a generating system's frequency response mode.
- Explicit recognition of power system security considerations, including interactions causing instability, in considering exemption or variation applications.
- Clarification of the extent and conditions for standing variations.

The draft PFRR has also been updated with minor drafting amendments.

After considering all submissions, AEMO's draft proposal is to make the Primary Frequency Response Requirements in the form published with this draft report, with a proposed effective date of **8 May 2023**.

Consultation notice

AEMO invites written submissions from interested persons on the draft proposal and issues identified in this draft report to pfr@aemo.com.au by **5:00 pm (Melbourne time) on 21 March 2023**.

¹ These obligations had previously been set to sunset on 4 June 2023.

Submissions may make alternative or additional proposals you consider may better meet the objectives of this consultation and the national electricity objective in section 7 of the National Electricity Law. Please include supporting reasons.

Please note the following important information about submissions:

- All submissions will be published on AEMO's website, other than confidential content.
- Please identify any parts of your submission that you wish to remain confidential, and explain why. AEMO may still publish that information if it does not consider it to be confidential, but will consult with you before doing so. Material identified as confidential may be given less weight in the decision-making process than material that is published.
- Submissions received after the closing date and time will not be valid, and AEMO is not obliged to consider them. Any late submissions should explain the reason for lateness and the detriment to you if AEMO does not consider your submission.

Interested persons can request a meeting with AEMO to discuss any particularly complex, sensitive or confidential matters relating to the proposal. Please refer to NER 8.9.1(k). Meeting requests must be received by the end of the submission period and include reasons for the request. AEMO will try to accommodate reasonable meeting requests but, where appropriate, may hold joint meetings with other stakeholders or convene a meeting with a broader industry group. Subject to confidentiality restrictions, AEMO will publish a summary of matters discussed at stakeholder meetings.

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1. Stakeholder consultation process

As required by National Electricity Rules (**NER**) 11.152.2 and 4.4.2A(a), AEMO is consulting on a proposal to amend the Primary Frequency Response Requirements (**PFRR**) (the **proposal**) in accordance with the standard rules consultation procedure in NER 8.9.2.

Note that this document uses terms defined in the NER and in the interim PFRR, which are intended to have the same meanings. There is a glossary of additional terms and abbreviations in Appendix A.

AEMO's process and expected timeline for this consultation are outlined below. Future dates may be adjusted and additional steps may be included as needed, as the consultation progresses.

Table 1 Consultation process and timeline

Consultation steps	Dates
Consultation paper published	6 December 2022
Submissions closed on consultation paper	16 January 2023
Draft report published	20 February 2023
Submissions due on draft report	21 March 2023
Final report published	Expected 8 May 2023

AEMO's consultation webpage for the proposal is at <https://aemo.com.au/consultations/current-and-closed-consultations/primary-frequency-response-requirements>. It contains all previous published papers and reports, written submissions, and other consultation documents or reference material (other than material identified as confidential).

In response to its consultation paper on the proposal, AEMO received four written submissions, from the Australian Energy Council (**AEC**), Delta Electricity, Origin Energy and Shell Energy.

AEMO thanks all stakeholders for their feedback on the proposal to date, which has been considered in preparing this draft report, and looks forward to further constructive engagement.

2. Background

2.1. Context for this consultation

On 8 September 2022, the Australian Energy Market Commission (**AEMC**) made the National Electricity Amendment (Primary frequency response incentive arrangements) Rule 2022 (**PFR incentives rule**).

The PFR incentives rule provides enduring arrangements to support the control of power system frequency through mandatory primary frequency response (**PFR**) and incentives for plant behaviour that reduces the overall cost of frequency regulation during normal operation. This consultation concerns those provisions in the PFR incentives rule that apply to the Primary Frequency Response Requirements (**PFRR**) only.

The transitional provisions of the PFR incentives rule require AEMO to develop and publish the PFRR by 8 May 2023, after consultation in accordance with NER 8.9.

2.2. NER requirements

AEMO published the current interim PFRR under NER 11.122.2 in accordance with the transitional provisions of the National Electricity Amendment (Mandatory primary frequency response) Rule 2020 (**Mandatory PFR rule**).

The PFRR are required to be made under NER 4.4.2A(a), while the remainder of NER 4.4.2A details what the PFRR should contain, and is reproduced here for convenience:

- (b) The *Primary Frequency Response Requirements* must include:
- (1) a requirement that *Scheduled Generators* and *Semi-Scheduled Generators* set their *generating systems* to operate in *frequency response mode* within one or more performance parameters (which may be specific to different types of *plant*), which:
 - (i) must include maximum allowable deadbands which must not be narrower than the *primary frequency control band* outside of which *Scheduled Generators* and *Semi-Scheduled Generators* must provide *primary frequency response*; and
 - (ii) may include (but are not limited to):
 - (A) droop; and
 - (B) response time,(the *primary frequency response parameters*);
 - (2) subject to rule 4.4.2B, the conditions or criteria on which a *Scheduled Generator* or *Semi-Scheduled Generator* may request, and *AEMO* may approve, a variation to, or exemption from, any *primary frequency response parameters* applicable to its *scheduled generating system* or *semi-scheduled generating system*;
 - (3) the process and timing for an application for a variation to, or exemption from, any *primary frequency response parameters* applicable to a *scheduled generating system* or *semi-scheduled generating system*, and the process for approval by *AEMO* of such variation or exemption; and

- (4) details of the information to be provided by *Scheduled Generators* and *Semi-Scheduled Generators* to verify compliance with the *Primary Frequency Response Requirements* and any compliance audits or tests to be conducted by *AEMO*.
- (c) The *Primary Frequency Response Requirements* must not require a *Scheduled Generator* or *Semi-Scheduled Generator* to:
 - (1) maintain stored energy in its *generating system* for the purposes of satisfying clause 4.4.2(c1); or
 - (2) install or modify monitoring equipment to monitor and record the *primary frequency response* of its *generating system* to changes in the *frequency* of the *power system* for the purpose of verifying the *Scheduled Generator's* or *Semi-Scheduled Generator's* compliance with clause 4.4.2(c1).
- (d) *AEMO* must publish on its website and maintain, a register of *Scheduled Generators* and *Semi-Scheduled Generators* who have been granted a variation or exemption from any *primary frequency response parameters* in the *Primary Frequency Response Requirements*.

NER 4.4.2B details the variation and exemption process referred to in NER 4.4.2A(b)(3), as follows:

- (a) In considering whether to approve an exemption from, or a variation to, any of the *primary frequency response parameters* applicable to a *Scheduled Generator's* or *Semi-Scheduled Generator's generating system*, *AEMO* must have regard to:
 - (1) the capability of the *generating system* to operate in *frequency response mode*;
 - (2) the stability of the *generating system* when operating in *frequency response mode*, and the potential impact this may have on *power system security*;
 - (3) any other physical characteristics of the *generating system* which may affect its ability to operate in *frequency response mode*, including (but not limited to) *dispatch inflexibility profile*, operating requirements, or *energy constraints*; and
 - (4) whether the *Scheduled Generator* or *Semi-Scheduled Generator* has been able to establish to *AEMO's* reasonable satisfaction that the implementation of the *primary frequency response parameters* applicable to that *Scheduled Generator's* or *Semi-Scheduled Generator's generating system* will be unreasonably onerous having regard to (among other things):
 - (i) the likely costs of modifying the *generating system* to be able to operate in *frequency response mode*; and
 - (ii) the likely operation and maintenance costs of operating the *generating system* in *frequency response mode*,

relative to the revenue earned from the provision of *energy* and *market ancillary services* by the *generating system* in relation to its operation in the *NEM* during the 12 months prior to the date of the application for exemption or variation, as applicable.
- (b) A dispute between *AEMO* and a *Scheduled Generator* or *Semi-Scheduled Generator* relating to a variation or exemption from any of the *primary frequency response*

parameters applicable to a Scheduled Generator's or Semi-Scheduled Generator's generating system may be determined under rule 8.2.

- (c) Information provided to AEMO by a *Scheduled Generator* or *Semi-Scheduled Generator* as part of an application for variation or exemption under clause 4.4.2B(a)(4) is *confidential information*.

2.3. The national electricity objective

Within the specific requirements of the NER applicable to this proposal, AEMO will seek to make a determination that is consistent with the national electricity objective (NEO) and, where considering options, to select the one best aligned with the NEO.

The NEO is expressed in section 7 of the National Electricity Law as:

to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to:

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

3. List of material issues

The key material issues arising from the proposal or raised in submissions are listed in Table 2.

Table 2 List of material issues

No.	Issue	Raised by
1.	Transitional Issues	AEMO
2.	Exemptions and Variations	AEMO, Delta Electricity
3.	Changes to Affected GS	AEMO, Delta Electricity
4.	Testing and Demonstration of Stability	AEMO, Delta Electricity
5.	Demonstrating Compliance with the PFRR	AEMO, Delta Electricity
6.	Clarification of Relationship between PFR and MASS	AEMO, Delta Electricity, Shell Energy
7.	Other Drafting and Technical Considerations	AEMO, AEC, Delta Electricity, Shell Energy
8.	Provision of PFR in Conjunction with Energy Dispatch	AEMO, AEC, Delta Electricity, Origin Energy, Shell Energy

Each of the material issues in Table 2 is discussed in Section 4.

4. Discussion of material issues

4.1. Transitional issues

4.1.1. Issue summary and submissions

As noted in the consultation paper, the interim PFRR were published in circumstances where AEMO needed to manage the initial implementation of mandatory PFR across existing scheduled and semi-scheduled generation, in particular, any potential adverse impact on Affected Generators and the power system.

With approximately 72% of the registered capacity of existing Affected Generators now meeting the interim PFRR (with approved exemptions or variations where applicable), the transitional processes are no longer considered necessary, but there were three issues that AEMO proposed to continue working on and sought submissions about:

1. **Affected Generators reliant on third parties to make changes to implement PFR settings** – AEMO proposed to continue working with those Affected Generators who had not yet achieved implementation due to their reliance on their original equipment manufacturers (**OEMs**) to get them to reach implementation. This work would continue outside of the PFRR.
2. **Affected Generators who have not submitted self-assessments** – Those Affected Generators who have not yet submitted their self-assessments or applications for variation or exemption should do so before completion of this consultation.
3. **Connection Applicants** – The process by which new Affected Generators will comply with the requirement to provide PFR will be subsumed by the connections process. There will no longer be any additional process within the PFRR.

AEMO did not receive any submissions directly on these issues.

4.1.2. AEMO's conclusion

AEMO does not propose to make any changes to the transitional requirements other than those in the draft PFRR published with the consultation paper.

4.2. Exemptions and variations

4.2.1. Issue summary and submissions

In the consultation paper, AEMO proposed to:

1. Amend the standing variations in section 6.6² of the PFRR by:
 - a. Changing the reference to “ambient temperature” in section 6.6(e) to “environmental conditions”.
 - b. Providing more a detailed process for notification in section 6.6(k).
 - c. Providing for a new standing variation in section 6.6(l) to address requests from Local Network Service Providers to operate Affected Generation in another mode.
2. Extend the timeframes for the provision of information and responses to applications for exemption or variation.

² Refers to the updated section numbers in the draft PFRR issued for consultation.

AEMO received one submission on these issues.

Delta Electricity

The existing set [of standing exemptions] could be enhanced by adding wording that connects point (a), (b), (d) and (e) to actions either automatic from installed controller reactions or manual by Unit operator actions.

Does point (j) need amending? Reading it completely in combination with the wording in the opening sentence can be interpreted to mean that a unit is never required to provide PFR Should it be saying “beyond the limit...” rather than “to the limit ...” or should the sentence include words to read something like “to observe the limit...” meaning the a GPS might contain permissives whereby PFR can be deselected so that specific GPS performance as approved can be met?

In general regarding possible variations, unit responses from units such as at Vales Point are more often reduced in overall PFR reaction rather than completely removed. The PFRR could perhaps explore by way of technology examples how aspects of the PFRR may be temporarily reduced, rather than completely withdrawn, by automatic or manual control reactions to secure a Unit and prevent interruption. Is it therefore correctly worded to say an “Affected GS will not be required to provide PFR” in such circumstances? Maybe better wording is to describe some limitations as representing PFR that has a reduced continuity of response or an early withdrawal of response due to certain conditions.

...

Considering the present frequency condition, the timeframes could be longer. Further MNBPFRR implemented since 40% of first tranche implementation seems to have no noticeable improving effect suggesting urgency for further implementations does not exist. However, if the exemptions or variations are considered by AEMO, in consultation with the affected GS, to potentially pose significant causation on erraticism of frequency as being experienced in the local area of the affected GS, the length for considerations and response are perhaps too long and should be maintained as in the interim PFRR.

...

Some response is reduced rather than completely removed in some automatic unit responses. The PFRR could perhaps explore by way of technology examples how aspects of the PFRR may be temporarily reduced, rather than completely withdrawn, by automatic or manual control reactions to secure a Unit and prevent interruption.

4.2.2. AEMO's assessment

Standing Variations

Delta Electricity's suggestion of differentiating between automated actions initiated by an installed controller or manual actions in paragraphs (a), (b), (d) and (e) appears unnecessary as there is no need to apply the variation differently based on how the action is initiated.

AEMO confirms that paragraph (j) is intended to require Affected Generators to provide PFR to the extent they can do so within the limits of their GPS, not to exempt them from providing PFR entirely. AEMO agrees there is merit in clarifying this paragraph to avoid any unintended interpretation.

Delta Electricity also suggested that the opening words in section 6.6 (“Affected GS will not be required to provide PFR”) might be better expressed to indicate limitations that reduce continuity of response, or early withdrawal.

AEMO considers that there is scope for section 6.6 to clarify that the listed conditions only vary the PFR requirement to the extent that they impact the Affected GS' capability to provide PFR.

AEMO considers that section 6.6 already allows significant flexibility in dealing with technology specific variation issues, and that technology specific examples would not be of benefit here.

In further reviewing the draft PFRR, AEMO noticed that paragraph (l) (responding to an LNSP request) should have included a notification process, similar to paragraph (k).

Timeframes for responses to applications

AEMO notes the absence of any significant concerns over the extension of these timeframes.

4.2.3. AEMO's conclusion

AEMO has included the following amendments in the draft PFRR published with this draft report:

- The introductory words of section 6.6 to confirm that the existence of the listed conditions relieves the PFR requirement only to the extent of the impact (so that a reduced PFR response should still be provided where that capability remains).
- Section 6.6(j) to clarify that an Affected GS is not required to provide PFR to the extent that would require operation outside the limits of its GPS.
- Section 6.6(l) to add a notification process.

4.3. Changes to Affected GS

4.3.1. Issue summary and submissions

AEMO also considered in the consultation paper the process by which changes to Affected GS should be addressed, and which was embodied in the proposed new section 6.8 of the PFRR.

AEMO received one submission on these issues.

Delta Electricity

Any renegeing of an existing exemption or variation is subject to the wording of the Rules and the interim PFRR. For future exemptions and variations, the proposed PFRR section 6.8 could apply once acceptable. The need to revisit probably depends on what is being altered and so a review of the PFRR capability of each unit may already be contained by inference via the Rule 5.3.9 and relevant AEMO processes for alterations. The PFRR may need only reference these other Rules and instruments if at all needing a change on this point and, at the very least, a check and confirmation that the Rules on PFRR and other Rules permit AEMO to revisit any approved variation or exemption is recommended to be done prior to final determination of this aspect of the revision.

...

The PFRR Rules don't appear to support what AEMO is seeking as proposed in section 6.8. There are perhaps other Rules that could be referred to that may support revisiting the PFRR capability of a Unit. Without specific PFRR Rules that support the revisiting, AEMO should either seek to link section 6.8 to other Rules that potentially support it or otherwise omit it until a future Rule change can establish the requirement.

...

The urgency for participants to continually communicate with AEMO on changes to the PFRR capability is not present as mandatory PFR has produced narrowing of frequency.

The PFRR is only meant to define minimum expectations. Variations to plant response that remain above the minimum expected and above Generator Performance Standards may not need regular discussion between the participant and AEMO under the existing Rules. If additional Rules are required to support future frequency control efforts such as system tuning, then a new Rule change request appears to be needed.

4.3.2. AEMO's assessment

AEMO's proposed section 6.8³ is limited to an Affected GS for which AEMO has granted an exemption or variation that provides relief from the mandatory PFR obligation that would

³ Renumbered to 6.7 in the draft PFRR published with this report.

otherwise apply under the NER. In accordance with NER 4.4.2B, in approving an exemption or variation AEMO is required to consider whether the capability of the generating system makes it unreasonable to comply with the PFR obligation or parameters. If that underlying capability changes, the basis for the approval may no longer be valid and should logically be reviewed to confirm eligibility. This review (and, if necessary, variation or revocation) of exemptions and variations does not require any explicit rule – authority to do so is inherent in AEMO’s approval function.

The PFRR will not require Affected Generators to communicate continually on changes to PFR capability, but rather to contact AEMO if they are proposing substantive changes to the configuration of relevant plant that has a current exemption or variation. AEMO notes that some minor drafting improvements may help to clarify when notification is required, and the options available to the relevant Affected Generator. The need to notify AEMO of such substantive modifications is already noted in AEMO’s initial approval of Variations to relevant plant.

NER 5.3.9 is not directly relevant as it is concerned with the impact of generating system alterations on the technical requirements contained in the GPS, while PFR is a power system security obligation under NER 4.4.2.

4.3.3. AEMO’s conclusion

AEMO proposes to retain section 6.8 (now 6.7) in the draft PFRR, with minor drafting changes, requiring an Affected Generator to advise AEMO of any substantive change to the configuration of an Affected GS with a current exemption or variation, and either re-apply or propose PFR Settings within the PFR parameters.

4.4. Demonstrating compliance with the PFRR

4.4.1. Issue summary and submissions

Although AEMO did not propose any changes to the section on compliance in the interim PFRR, AEMO’s consultation paper sought submissions on whether it should be proposing any.

AEMO received one submission on this issue.

Delta Electricity

A unit being considered compliant or non-compliant may become more difficult to demonstrate should erraticism being experienced over a 20-30s period become stronger (i.e. increased peak to peak amplitude). The PFRR would benefit from statements on the erraticism as being outside of the capability of PFR to control.

4.4.2. AEMO’s assessment

AEMO considers that the matter raised by Delta Electricity on this issue is most relevant to the testing and demonstration of stability discussed in section 4.5. The core PFR compliance obligation is to operate an Affected GS within the parameters specified in the PFRR, subject to approved exemptions or variations. If an Affected GS is found to be operating unstably in frequency response mode, AEMO will work the Affected Generator to vary the settings under section 6.1.2 of the PFRR.

4.4.3. AEMO's conclusion

AEMO proposes not to change the draft PFRR section on compliance (section 8) from the corresponding section 9 of the interim PFRR.

4.5. Testing and demonstration of stability

4.5.1. Issue summary and submissions

To address issues associated with some interactions between PFR delivery and the overall control of active power by some Affected GSs, AEMO proposed to amend section 8.2 of the PFRR to identify that PFR testing should include simultaneous testing of PFR and control of active power output.

AEMO received one submission on this issue.

Delta Electricity

In the present condition, the 50mHz erraticism may on occasion impede effective determination of “stability”. The PFRR stability expectations would be improved by including an AEMO viewpoint regarding the 50mHz variations which, as previously reported by AEMO, appeared to be accepting that the erraticism is uncontrollable. Providing comment on the erraticism condition in the PFRR, excusing reactions of Units to the erraticism where such reactions hinder a determination of stability, could be a worthwhile inclusion for AEMO to consider.

4.5.2. AEMO's assessment

The additional requirement to simultaneously test PFR and control of active power is based on experience to date with implementation of PFR Settings on Affected GSs. This is particularly in relation to control systems on semi-scheduled generation, where some challenges have been identified in ongoing coordination of PFR and active power control.

Regarding the issue raised by Delta Electricity on erratic movements in power system frequency, if material power system security issues are identified, AEMO will work with industry to determine the underlying causes and implement appropriate remedial actions. Beyond this, where external factors within the power system are identified that materially impact an Affected Generator's ability to meet its PFRR obligations and are beyond its control, AEMO will work with the Affected Generator to consider whether an exemption or variation could be granted.

Similarly, if an Affected GS is operating unstably due to its PFR Settings the Affected Generator could apply for a variation under section 6.1.1 or 6.1.2 of the PFRR.

4.5.3. AEMO's conclusion

AEMO proposes to retain the amendment to section 8.2 in the draft PFRR, identifying that testing should include simultaneous testing of PFR and active power output. Changes have also been made to section 6.1.2 to confirm that variations can consider the capabilities of an Affected GS in the context of broader power system issues that may impact it.

4.6. Clarification of Relationship between PFR and MASS

4.6.1. Issue summary and submissions

In the consultation paper, AEMO considered that there should be closer cross-references between the PFR and the Market Ancillary Service Specification (**MASS**) and proposed certain changes to section 2.3 of the PFR.

Two submissions were received on this issue.

Delta Electricity

Linking to the MASS in appropriate ways that align with the Rules to clarify expectations of either the MASS or the PFR is supported but ambiguous descriptions that vary in interpretation from that made from the Rules wording, or the intent of the Rules as described in determinations that supported the relevant Rule, are to be avoided.

Clarifying whether dispatch instructions, where mentioned, is meant to be referring to energy and/or FCAS dispatch, is considered necessary at various places throughout the PFR.

Shell Energy:

Shell Energy supports the change to section 2.3 of the PFR to provide cross reference to the MASS.

4.6.2. AEMO's assessment

The cross-referencing with the MASS in section 2.3 is complete. The matters raised in Delta Electricity's submission regarding the type of dispatch instructions referred to have been addressed, and are discussed in section 4.8 of this draft report.

4.6.3. AEMO's conclusion

AEMO does not propose to make any further changes to the MASS cross-referencing in the draft PFR.

4.7. Other drafting and technical considerations

4.7.1. Issue summary and submissions

In the consultation paper, AEMO sought submissions on whether there were any other drafting or technical considerations that should be considered for inclusion or amendment in the PFR.

Australian Energy Council:

In section 2.2, the draft PFR correctly recognises that the NER 4.4.2A(c) states that the PFR must not require the maintenance of stored energy. Not requiring either "stored energy", "headroom" nor "footroom" is the intent of the Rule, and AEMO's present implementation, however expectations regarding the latter two may not be obvious from applying the term "stored energy" alone. Whilst the umbrella term "stored energy" may be adequate for the NER, the AEC suggests the expectations could be more explicitly defined in the PFR as meaning that affected Generating Systems (GS) do not need to provide "stored energy, headroom or footroom".

In section 2.3(a) and 2.3(b) it would be worth after "the Affected GS' output is to be varied in accordance with the PFR Settings" including "subject to section 2.2" to make it clearer that GS' output variations do not require headroom or footroom.

In section 2.3(c) it would be worth clarifying that the "dispatch instruction" is a "4.9.3A dispatch instruction" to affirm that it is the result of an ancillary service.

...

Section 3.2.2 appears to be superfluous to section 3.2.1.

Delta Electricity:

Section 2.2 is not complete in the sense that it only describes the obligation on stored energy which is, from some interpretations, only relevant to a raise response. Under the Rule as determined and explained by the AEMC in its determination, the expectation was that it applies equally to the headroom available on a unit to move in raising support rather than simply stored energy that may preserve energy to deliver rapid raise support. Some Units cannot provide a rapid PFR raise response unless there is storage provision maintained in the prime-moving energy to do so and the PFR Rule 4.4.2A(c) is meant to ensure participants are excused from needing to store energy (or headroom as the AEMC explained in the determination) to provide PFR. Similarly, but apparently outside the Rule as drafted, in the transitioning market, conventional steam fired units are regularly experiencing operations to low loads below levels where the Unit can sustain a lower PFR reaction and some newer units won't move at all when operated at a low load limit. Excuse from a PFR lowering reaction due to a lack of "footroom", as is considered to be permitted via other Rules on expected performance standards, is not adequately explained in the interim PFRR or the proposed PFRR, except perhaps implied in the standing variations.

Every clause of the PFRR should refer to the relevant Rule it is generated from by including the Rule reference in brackets after the title of each section of the PFRR. The wording of the PFRR clauses should pay very close attention to the Rules and not provide details not supported by relevant Rules nor vary from the intentions of the Rules as documented in the determination reports that produced the Rule. Providing requirements or procedural steps that have no Rules basis but appear necessary in support of PFR delivery should be clearly separated from clauses designed from Rules directed requirements. Clauses without a clear Rules basis should only be included with reasoning that proves the necessity for them, and if the necessity is not provable, the requirement should be removed or reduced to being a suggestion by AEMO as to how participants may proceed in order to comply with definitive clauses that are based on the Rules.

Shell Energy:

We also consider that this section would benefit from cross reference to the NER regarding the type of dispatch instruction that is issued for each service as well as clarity that dispatch outcomes in each case would also be subject to Section 2.2 of the PFRR. We have set out our suggested improvements to section 2.3 of the PFRR as follows to provide additional clarity and enhance compliance:

Section 2.3. Interaction between dispatch instructions and PFR Settings

*(a) Where an Affected Generator receives a **NER 4.9.2** dispatch instruction in respect of an Affected GS for a quantity of energy greater than 0 MW, the Affected GS' output is to be varied in accordance with the PFR Settings **subject to section 2.2**. If the dispatch instruction is received by AGC, the desired output should be the summation of the AGC setpoint and the PFR Settings as described in section 10.3 of the market ancillary service specification (MASS).*

*(b) Where an Affected Generator receives a **NER 4.9.3A** dispatch instruction in respect of an Affected GS for a quantity of Regulation FCAS greater than 0 MW, the Affected GS' desired output should be the summation of the AGC setpoint and the PFR Settings **subject to section 2.2** as required by section 10.3 of the MASS.*

*(c) Where an Affected Generator receives a **NER 4.9.3A** dispatch instruction in respect of an Affected GS for a quantity of Contingency FCAS, but that Affected GS is not dispatched to provide energy in the same dispatch trading interval, the Affected GS must comply with the requirements for the relevant Contingency FCAS, as set out in the MASS.*

...

With regard to question 13, we also consider that section 2.2 should be updated to indicate that an Affected GS is not required to maintain headroom or foot room in the submission of its energy or FCAS bids for the provision of PFR. We have set out our suggested improvement as follows.

As required by NER 4.4.2A(c), there is no requirement for Affected Generators to maintain **headroom, foot room or** stored energy in their Affected GSs for the purpose of providing PFR.

Delta Electricity

Delta Electricity is concerned that rigid deployment of the primary frequency control band and the available support at times from generators, sometimes without adequate headroom or footroom, are combining and having impact on the even distribution of frequency. Daily charts of the distribution shows signs of overregulating to the PFCB yielding a far from bell-shaped distribution around the expected 50Hz nominal and distortions that suggest raise services are quite different in effect and dominance to that of lower services on certain days. The tightness of the band and the lack of routine system-wide examination of the coordination between various controllers on machines (mechanical-hydraulic governors and DCS supported frequency

control) and AEMO's AGC regulation FCAS and dispatch targeting, are considered to be contributing factors as to why there remains a general erraticism in frequency that was not present in the 20th century or the early years of the market in the early 21st century.

Delta Electricity is also concerned that frequency erraticism in the present NEM means that frequency steadiness may not be controllable fast enough by any available PFR as currently designed. Continued unchecked, it is possible the maintenance of tight PFCBs and the erraticism will effect longer term damage on machines increasing unplanned downtime and outage works to correct but, without effective elimination or better dampening control of the erraticism, may also produce repeating failures in speed governing equipment.

...

The Present Frequency Condition

A single generating unit is not designed nor reasonably expected to recover frequency of the entire system back to 50Hz on its own. All machines, in coordination with the reactions of all other machines and load as steered by a smart central dispatch from AEMOs NEMDE and AGC, can do this. Each mechanical-hydraulic governor reacts to speed changes before the unit load controller returns the Unit to dispatch setpoint. Unit FCAS controllers of a machine are designed to proportionally correct unit setpoint to provide the sustained response until frequency returns inside expected deadbands.

A mechanical-hydraulic governor reaction with supporting stored energy is a natural PFR delivery system i.e., the reaction provides a response in output proportional to the detected speed change (not an absolute frequency value) according to the 'droop' percentage ratio. These controllers have no deadband but from examination of recorded 4s sampled frequency data, "deadbands" result from the mechanical-hydraulic reaction which are statistically wider than the assigned PFCB and are not adjustable. A PFCB set inside this resultant deadband and deploying correcting absolute frequency controllers installed in the Unit DCS is probably uncoordinated with the mechanical-hydraulic reaction and therefore contributing to erraticism.

DCS controllers, that aim to sustain the Unit correction to any detected frequency deviation from 50Hz, attempt to compliment the initial mechanical governor reaction. Assigned deadbands in these controllers are adjustable and should be specifically determined by investigation and consultation between the Generator and the system operator so that responses coordinate well with the local mechanical-hydraulic governor, with other nearby synchronous units and also with any AEMO deployed frequency control. Continuous overcorrection is to be avoided in order to avoid unnecessary wear and tear that raises the potential for premature failure in the mechanical-hydraulic mechanisms which are expensive to maintain in terms of both parts and the length of Unit downtime to repair. In the specific case of ageing units such as Vales Point, overcorrection could also accelerate the potential end of life of the two units.

Uncontrolled erraticism in frequency will be ageing all machines more than a steadier frequency condition would. Rigid assignment of a tight PFCB to all machines is considered to be contributing to this erraticism and therefore accelerating the potential for failure as the various machines age further and retire. It is considered likely that tuning efforts, centrally coordinated by AEMO, inclusive of deploying subtle changes to assigned deadbands of the controllers of the frequency controllers on each Unit, where possible, could achieve a steadier frequency outcome as may attention to detail about the overall PFR quantity required at any given time or, perhaps more importantly, coordinated efforts in general to reduce uncoordinated reactions.

Mandatory PFR has not reduced the erraticism as can be observed in the 50mHz variations over a 20-30s period and there are occasional signs the amplitude of the variations is increasing. It is considered that lack of coordination of the overall frequency control delivery could be responsible.

Variety in control

As mentioned, controllers between power stations may need better coordination with nearby units (or even units less nearby such as can be influenced in the applied settings of power system stabilisers included in the automatic voltage regulators of each unit).

The mechanical-hydraulic governors react to changes in turbine speed and the reaction is automatically associated with the delivery of the response.

DCS Frequency controllers, on the other hand, rely on frequency detection, processing time, target correction and target delivery and the frequency detection system of such controllers is quite separate in location and design to the speed detector/controller of the mechanical systems. Are all these elements at any Unit coordinated well enough and should AEMO be providing a lead role in coordinating efforts to improve the overall control of frequency under Rule 4.4.1(a)?

Are close units with different governing technologies (e.g. mechanical-hydraulic and electro-hydraulic) adequately coordinated?

Possibly related to aspects of frequency coordination, the AEMO AGC appears to ramp the energy target delivery to units that also control energy ramping locally. Is the duplication of such ramping controls, which could also be contributing to frequency erraticism, necessary?

Any disconnection between the intent and expectations of frequency control and the actual delivery of that control, highlights more possibilities for why frequency erraticism remains an observed problem.

AGC contributions to the erraticism

AEMO may be also aware, as is indicated by decisions taken in January 2021 to reverse some AGC changes that improved frequency distribution early in the PFR implementation, that the AGC dispatch delivery contributes to the erraticism being experienced.

Prior to the removal of the AGC changes, the frequency distribution was superior to that which has continued since, despite a doubling of MW capacity with MNBPFRR installed.

It is considered that AEMO assigning technical resources to investigate these concerns and seek tuning outcomes, including a greater variety in the applied deadbands in locations in the NEM, could improve steadiness and therefore also complement efforts in the market place to incentivise performance via the PFR incentives being designed in the Frequency Performance Payments procedural changes to the Regulation FCAS Contributions Factor Procedure.

Rise in frequency events without identifiable Contingent cause

There are certainly far fewer frequency excursions beyond the NOFB as a result of the narrowing of the outer extremities of normal frequency distribution but there is now a growing proportion of events that appear to be associated with rapid changes in load and large numbers of aggregated generating sources despite the MNBPFRR. Are these events occurring during the time when there is a lack of headroom or footroom for PFR? Such events should be routinely included for in the quarterly reporting on frequency conditions.

...

The full implementation of Mandatory PFR is arguably a demonstrable overreach beyond effective PFR needed within the capabilities. Far less quantities of MWs on PFCB control settings demonstrably performed the same narrowing that increasing Mandatory PFR quantities is delivering and erraticism continues to exist that Mandatory PFR is not controlling as is reportedly understood and accepted by AEMO.

A large missing element in the PFRR description is that related to the AEMO AGC to Unit dispatch interface. Elements on this could be included for to discuss:

- AGC dispatch and targeting to units that can affect PFR,
- Expected frequency distribution,
- Improved understanding of the overall coordination issues such as:
 - how natural PFR from mechanical-hydraulic governors works (reacts to speed change and not absolute frequency),
 - how units may interact with other units
 - how the AVR stabiliser settings may be important contributors
 - how PFR, FCAS regulation and 5minute energy target decisions are expected by AEMO to interact
- softening the wording of the defined PFCB to make it the default minimum deadband but also included for in a new section discussing AEMO to unit tuning and the possible need to vary the deadband as part of toolbox of actions to reduce the overall erraticism.

However, modifying the PFRR probably won't fix frequency erraticism. Re-evaluating the situation and seeking a different Rule change to expand on the meaning of Rule 4.4.1(a) and including tuning efforts in the Rules might.

...

The self-assessment and variation process seemed to work and requires no changes but closer adherence to Rules, the words the PFRR uses in support of the Rules and adjustment in the expectations from the Rules AEMO has, is recommended.

...

Section 3.2 remains problematic in the assigned rigidity of the same deadband application on every NEM Unit. It is likely some flexibility in deadband settings between Units is needed for better overall coordination. The PFRR Rules do not mandate that all Units carry the same deadband. The wording of section 3.2.2 remains not necessarily in accordance with the expectations of the Rule 4.4.2A(b)(1)(i) which defines that the PFRR “must include maximum allowable deadbands which must not be narrower than the primary frequency control band”. It is suggested that in finalising the PFRR, AEMO consider some options for future tuning that might seek to vary from words that require every unit to be set “equal to the PFCB” as presently proposed. An alternative in

support of better overall tuning of frequency control the NEM, could be conceived where, with agreement from affected GS and where easy to adjust, AEMO assigns a variety of slightly wider deadbands to distinct areas of the NEM.

Clarity of the expectations of PFRR technical requirements could also be improved by way of example technology attachments to the PFRR that present various best PFRR application examples from various technology sets deployed in the NEM including detailed breakdowns of how multiple controllers may be used to provide the total PFR response from a single unit.

4.7.2. AEMO's assessment

Slow frequency oscillations

Delta Electricity raised several matters in relation to ongoing frequency stability, and how it might be addressed both through the PFRR, and tuning of AEMO's AGC system.

Delta Electricity's submission discusses the ongoing slow frequency oscillations that can be observed in NEM frequency. These ongoing frequency oscillations have a typical period of 18-24 seconds, and a varying amplitude, typically of several tens of mHz.

In principle, ongoing oscillations in a key power system quantity such as frequency, even at relatively low amplitude, are undesirable and ideally should be reduced, or even eliminated. These ongoing frequency changes will result in ongoing low levels of frequency response from plant, with varying impacts, depending on plant technology, configuration and tuning.

These slow frequency oscillations cannot be reproduced with power system models available to AEMO, and AEMO is not aware of any historical analysis of similar slow frequency oscillations in the NEM. There appears to be only very limited analysis of similar slow oscillations in other power systems.

These slow common-mode oscillations in frequency are quite distinct from the significantly faster, and of far smaller amplitude, inter-area oscillations seen in the NEM, which have been extensively analysed over several decades. In the absence of widespread synchronised monitoring equipment, it is difficult to rigorously measure exactly which plant is contributing to, responding to, or damping these, slow frequency oscillations.

AEMO is aware that control tuning of large coal-fired plant has been suggested as a contributor to these ongoing frequency oscillations, and that control changes made during implementation of PFR Settings for these plant during 2020 and 2021 could also play a role. The configuration and tuning of AEMO's AGC system has also been suggested as a factor, though it is noted that it lies outside the matters specified in the PFRR.

Where it can be demonstrated that control tuning on specific plant is a factor in these common-mode frequency oscillations, and that altering their control settings could be effective in alleviating them, the PFRR already permits bespoke, plant specific, variations in plant settings, so as to manage plant stability or power system security. Variations in PFR Settings have been previously agreed for several plant, including large coal-fired plant. AEMO is proposing minor changes to the draft PFRR to make this clear, as noted in section 4.5.2.

It is unclear whether simply modifying the universal minimum PFR requirements for all plant types and technologies would be necessary, sufficient, or effective, to address these slow oscillations in NEM frequency. Universal widening of frequency response deadbands, for example, could reasonably be expected to increase the level of ongoing frequency movement, without necessarily reducing the response required from any individual plant to that movement, or necessarily addressing ongoing small frequency oscillations.

Site-specific control adjustment, utilising the existing PFR variation mechanisms, is an available mechanism which currently appears the most effective option to address ongoing small frequency oscillations.

While ongoing tuning of AEMO's AGC system could also play a role in improving the overall stability of NEM frequency control under normal conditions, it is again noted that AGC arrangements are outside the scope of the PFRR. AEMO is open to engaging further on this matter via a suitable working group.

References to headroom and footroom

AEMO appreciates the detailed feedback in submissions on AEMO's proposed amendments to sections 2.2 and 2.3 of the PFRR.

While the terms "headroom" and "footroom" are used as a form of shorthand in the industry, they are not defined terms in the NER. Notably, the AEMC did not use the terms in making the PFR incentives rule and only refers to these a handful of times in the accompanying final determination.

Nevertheless, based on experience and previous discussions with Affected Generators, AEMO considers that amending section 2.2 as suggested to refer to headroom and footroom would improve clarity.

Is section 3.2.2 of the PFRR consistent with NER 4.4.2A(b)(1)(i)?

NER 4.4.2A(b)(1)(i) states:

(b) The *Primary Frequency Response Requirements* must include:

- (1) a requirement that *Scheduled Generators* and *Semi-Scheduled Generators* set their *generating systems* to operate in *frequency response mode* within one or more performance parameters (which may be specific to different types of *plant*), which:
 - (i) must include maximum allowable deadbands which must not be narrower than the *primary frequency control band* outside of which *Scheduled Generators* and *Semi-Scheduled Generators* must provide *primary frequency response*; and
 - ...

The requirement is that the maximum allowable deadband **must not be narrower than the PFCB**. Section 3.2.2 of the PFRR is consistent with NER 4.4.2A(b)(1)(i) because the required deadband is not narrower than the PFCB.

Cross-referencing the NER

AEMO is cognisant of the need to ensure that the provisions in the PFRR are consistent and work in harmony with relevant provisions in the NER. To that end, as further discussed in section 4.8, AEMO proposes to address the potential inconsistency associated with the NER linkage of mandatory PFR with dispatch instructions to generate under NER 4.9.2. AEMO does not consider that there would be benefit in a widespread cross-referencing of the PFRR to specific sections of the NER. The PFRR are developed and updated through rules consultation processes and, like any similar instrument, should add appropriate explanation and guidance on application at a level of specificity that is not prescribed in rules – nor does it need to be. The NER prescribes the minimum content of the PFRR, and does not provide an exhaustive list.

Relationship between sections 3.2.1 and 3.2.2

AEMO agrees that sections 3.2.1 and 3.2.2 can be merged.

Other drafting amendments

AEMO has undertaken a further review of the early draft PFRR provided with the consultation paper and made some minor drafting changes, including updated references. AEMO has also moved and streamlined the original clause 6.7, dealing with changes to PFR Settings after their initial approval. A new section 2.4 now includes the requirement that subsequent changes to PFR Settings require AEMO approval, and confirms that an exemption or variation application may be submitted if necessary at a later stage.

4.7.3. AEMO's conclusion

AEMO proposes to amend the following sections of the draft PFRR:

- Section 2.2 to include the suggested reference to headroom and footroom.
- Sections 3.2.1 and 3.2.2 to streamline and combine them.
- Section 6.1.2 to clarify possible basis for individual variations to settings.
- Section 6.7 to streamline the process for future changes to PFR Settings and move this to a new section 2.4.

4.8. Provision of PFR in conjunction with energy dispatch

4.8.1. Issue summary and submissions

In the consultation paper, AEMO proposed to amend section 4.3 of the PFRR in its application to a battery energy storage system (**BESS**) to clarify that there is no requirement for BESS to *inhibit* the provision of PFR when charging, and note an expectation that PFR Settings would, in fact, not change by reference to direction of flow.

AEMO emphasised the need for a consistent response from all plant, not just BESS, to support the resilience and predictability of the power system's response to disturbances and noted that it is considering a rule change proposal to address a number of issues relating to the continued application of PFR to BESS.

All submissions addressed this issue:

Australian Energy Council:

The change proposed to Section 4.3 has caused concern amongst AEC members. NER 4.4.2(c1) states that GS must provide mandatory PFR when generating a volume greater than zero MW. Clearly a GS generating a negative volume (i.e. a charging battery) is not generating a volume greater than zero and therefore the rules do not make it subject to mandatory PFR.

The proposed addition to the PFRR however states "It is expected that PFR Settings for battery energy storage system will not change by reference to the direction of energy flows for which they are dispatched". Prima facie this new wording appears inconsistent with NER4.4.2(c1) and the present implementation of mandatory PFR.

If it was AEMO's intent that battery energy storage be obliged to provide PFR when charging, then the AEC suggests it needs to first propose a rule change.

If however it was simply AEMO's intent to clarify that battery energy storage had the permission (but not the obligation) to provide PFR when charging, then the drafting requires improvement to remove the ambiguity. The AEC suggests the clarification may not be necessary and the proposed words could be set aside.

Delta Electricity:

Batteries are not required to provide PFR when they are charging and the proposed wording of the PFRR, whilst it can be reasoned to be supporting expectations AEMO prefers to be drawn from the Rules, should not go beyond what the Rules permit even if a 'free' response from a charging battery is wanted by AEMO. If AEMO considers the delivery to be mandatorily required, the Rule needs changing. If it is not, it shouldn't need suggesting in the PFRR which are considered should only support the Rules or at least distinguish between that which is supporting the Rules and that which is an AEMO preference not necessarily supported by the present Rules.

The section 4.3 should actually refer to the Rule to clarify the expectations.

...

PFR is not required on a BESS when charging as described by the Rules. The document defines what PFR "requirements" are which should not go beyond what the Rules mandate. The wording proposed for 4.3 is not helpful in describing that Units can optionally provide additional services to the that required by the Rules. The optional requirements can be asked for by AEMO but the options for participants to do so does not need to be written in the PFRR which should only describe what the Rules require.

Origin Energy:

Origin is not supportive of the proposed amendment of Section 4.3 to require battery energy storage systems to provide PFR when charging. While we acknowledge the importance of predictable unit response, this change is inconsistent with the intent of the PFR Incentive Arrangements final rule. The final rule clarifies that generators that are not dispatched in the energy market to generate electricity are not required to provide PFR. The AEMC concluded that the application of a PFR requirement to battery energy storage systems that are not dispatched to generate electricity would be "discriminatory, as other generation technologies cannot provide PFR unless they are online and generating".¹ We also note that requiring batteries to provide PFR when charging has the potential to increase the wear and tear and may reduce their effective asset life, which could impact the investment case for battery storage.

Shell Energy:

Shell Energy does not support AEMO's proposed amendment to Section 4.3 of the PFRR and question its inclusion from a rules compliance perspective. As noted in the Paper, the AEMC, in its final determination to the PFR incentive rule change, has provided additional and welcomed clarity that an Affected GS is not required to provide PFR unless it has been issued an energy market dispatch target greater than 0 MW. We support the AEMC providing additional clarity in this area. It is our view that the proposed amendments to the PFRR result in a lessening of clarity regarding this issue and could be interpreted as being in conflict with the Rules in this area. Whilst we agree that the Rules don't provide an explicit obligation that a battery energy storage system (BESS) must have a control system that switches off PFR when charging, we believe the PFRR should not contain a stated expectation that a BESS is required to continue to provide PFR when charging or not generating active energy output which in our view is contradictory to the Rules. However, we do recommend an amendment to existing section 4.3 as follows;

Subject to NER 4.4.2(c1), PFR must remain continuously enabled at the PFR Settings, unless agreed with AEMO, independent of ancillary services enablement.

This provides clarity that agreement from AEMO is not required when the provisions of NER 4.4.2(c1) apply.

It is worth reiterating why Shell Energy does not support the proposed amendment. Battery Energy Storage System (BESS) warranties include limitations on the amount of operating MWhs per day/year (energy limit). For example: a 100MW, 2hr BESS is usually warranted to one cycle a day, 200MWh. Every MWh discharged from a BESS uses up the warranted daily energy (MWh's) which cannot be recouped throughout the day for breach of BESS warranty. If a BESS is sitting idle at 0MW and the PFR requirement intermittently instructs the BESS to discharge 1MW or 10MW, then PFR is using up valuable and limited energy from the BESS warranted daily energy limit. If a reserve shortfall occurs later in the day after PFR has consumed the daily warranted energy the BESS may not be able to supply any energy against into the shortfall period. Therefore, it is prudent for AEMO to assume that if a BESS is scheduled for 0MW energy then they cannot provide PFR. Instead, AEMO should align to the incentives facing market participants and quarantine BESS daily energy for the higher value reserve shortfall or low supply/high demand periods.

4.8.2. AEMO's assessment

AEMO agrees that the proposed wording of section 4.3 of the PFRR could be interpreted as requiring BESS operators to provide PFR when charging, which would be inconsistent with the NER.

AEMO proposes to reword section 4.3 of the PFRR to make it clear that this is not a requirement and reference NER 4.4.2(c1), but also indicate that consistent settings are preferable from a power system operation perspective.

AEMO again notes its intention to propose a change to the NER to address the application of the mandatory PFR obligation to BESS when the 'integrating energy storage systems in the NEM' rule⁴ comes into full effect in June 2024.

4.8.3. AEMO's conclusion

AEMO will amend section 4.3 of the draft PFRR to remove any inference that BESS must be operated to provide PFR other than when generating. Minor amendments will also be made in sections 2.1 and 2.3 of the draft PFRR to better reflect NER 4.4.2(c1).

⁴ National Electricity Amendment (Integrating energy storage systems into the NEM) Rule 2021 No. 13, <https://www.aemc.gov.au/rule-changes/integrating-energy-storage-systems-nem>

5. Draft determination on proposal

Having considered the matters raised in submissions to the consultation paper, AEMO's draft determination is to make the Primary Frequency Response Requirements in the form published with this draft report, in accordance with NER 11.152.2 and 4.4.2A.

The published draft PFRR is marked up to show changes from the version issued with the consultation paper.

Appendix A. Glossary

Terms defined in the NER and the interim PFRR have the same meanings when used in this draft report. Other defined terms and acronyms are listed in the following table.

Term or acronym	Meaning
AEMC	Australian Energy Market Commission.
BESS	Battery energy storage system.
GPS	Generator performance standards.
Interim PFRR	AEMO's Interim Primary Frequency Response Requirements , dated 4 June 2020.
Mandatory PFR rule	The AEMC's National Electricity Amendment (Mandatory primary frequency response) Rule 2020 .
MASS	AEMO's Market Ancillary Service Specification .
OEM	Original equipment manufacturer.
PFCB	Primary frequency control band, as defined in the Frequency Operating Standard .
PFR	Primary frequency response.
PFR incentives rule	The AEMC's National Electricity Amendment (Primary frequency response incentive arrangements) Rule 2022 .
PFRR	Primary Frequency Response Requirements, the subject of this consultation.