FREQUENCY CONTROL RULE CHANGES

TECHNICAL WORKING GROUP MEETING

8 OCTOBER 2020

AEMC

Agenda

	Session 1 (11:00am – 1:00pm)
1.	Introductions and competition protocol
2.	Context and objective of the meeting
3.	Interactions with the Energy security board post-2025 market design
4.	AEMO frequency control update
5.	Fast frequency response market ancillary service
	Session 2 (2:00pm – 4:00pm)
6.	Primary frequency response incentive arrangements
7.	AEC frequency control working group briefing

1.
INTRODUCTIONS AND COMPETITION PROTOCOL

1.1. Introductions - Working Group Participants

MARKET BODIES

AEMC

Victoria Mollard – *EGM Security & Reliability*

Sebastien Henry – *Director*

Ben Hiron – *Senior Adviser*

Julian Eggleston – *Director*

David Reynolds – *Adviser*

AEMO

David Scott – *Regulatory Manager*

Andrew Groom – *Specialist, Operations*

Andrew Paver – *Principal analyst*

AER

Craig Oakeshott – *Director*

ESB

Joel Gilmore – ESS and ahead markets

Nicole Dodd -

ARENA

Jon Sibley - *Principal policy officer*

INDUSTRY ASSOCIATIONS

Australian Energy Council

Ben Skinner – *Secretariat*

Henry Gorniak – *CS Energy*

Simon Bolt – *Delta Electricity*

Darren Hunt – *AGL*

Clean Energy Council

Same Fyfield - *Goldwind*

Tom Geiser - *Neoen*

Kate Summers – *WSP*

Electricity Networks Association

Jill Cainey – *Secretariat*

Edward Selwood – *Essential Energy*

Jessica Hui - *Ausgrid*

CONSUMER REPRESENTATIVES

Public Interest Advocacy Centre

Miyuru Ediriweera

MARKET PARTICIPANTS

Enel X

Claire Richards

Energy Efficiency Council

Rob Murray-Leach

ERM Power

Ron Logan

Infigen Energy

Tahlia Nolan

Reposit Power

Dean Spaccavento

Tesla Energy

Josef Tadich

ACADEMIC INSTITUTIONS

RMIT University

Prf. Peter Sokolowski

2.
CONTEXT AND OBJECTIVE FOR THE MEETING

2.1 Background on the frequency control rule changes

- On 26 March 2020, the AEMC made a final rule to introduce to the NER a requirement for all scheduled and semi-scheduled generators to be responsive to changes in system frequency in accordance with performance parameters defined by AEMO. The mandatory PFR arrangement came into effect on 4 June 2020 and will sunset on **4 June 2023**.
- On 2 July 2020 the AEMC published a consultation paper to discuss issues raised by seven rule change requests related to the provision of system services in the NEM. Submissions to this paper closed on 13 August 2020.
- On 16 September 2020, the Commission extended the timeframes for the consultation on these rule change requests. The revised timeframes for the frequency control rule changes are:
    - *Fast frequency response market ancillary service:* Draft determination by **22 April 2021**
    - *Primary frequency response incentive arrangements*: Draft determination by **16 September 2021**
- The *Frequency control frameworks review (FCFR)* recognised the emerging need for more and faster frequency control and discussed how Fast frequency response (FFR) could be procured through the existing fast raise and lower ancillary service markets. The FCFR did not include a detailed investigation of new arrangements to incorporate or reward FFR in the NEM. Instead, it recommended that AEMO and the AEMC work together, and with stakeholders, to consider potential reforms to the contingency FCAS frameworks, including provision of inertia and FFR.
- A range of policy options for the provision of continuous primary frequency response were previously considered in detail by the AEMC through the 2018 FCFR and the determinations for the *Mandatory primary frequency response rule 2020*.
- The remaining objectives for the *Primary frequency response incentive arrangements* rule change include consideration of the appropriateness of the existing incentive arrangements for PFR and the development of enduring PFR arrangements to extend beyond June 2023.

2.1 Overview of the frequency control rule change requests

The frequency control rule changes form one arm of the AEMC's consultation on seven active rule changes related to provision of system services to support security and reliability in the National Electricity Market.

On 2 July 2020, the AEMC published a consultation paper setting out the issues and approach to the system services rule changes.

The frequency control rule changes are:

Primary frequency response incentive arrangements (ERC0263)

Proponent: AEMO

Initiated: 19 September 2019

Draft Determination: by 16 September 2021

This rule change follows on from the 2019 Primary frequency response(PFR) rule change requests which led to the Commission making a final rule, *Mandatory primary frequency response* in March 2020.

The Commission has committed to investigating alternative or complementary arrangements for PFR through the *Primary frequency response incentive arrangements* rule change.

Fast frequency response market ancillary service (ERC0296)

Proponent: Infigen

Initiated: 2 July 2020

Draft Determination: by 22 April 2021

This request proposes the introduction of new ancillary service markets for fast frequency response (FFR) to efficiently manage power system risks associated with reduced system inertia.

2.2 Frequency control rule changes - Objectives of this meeting

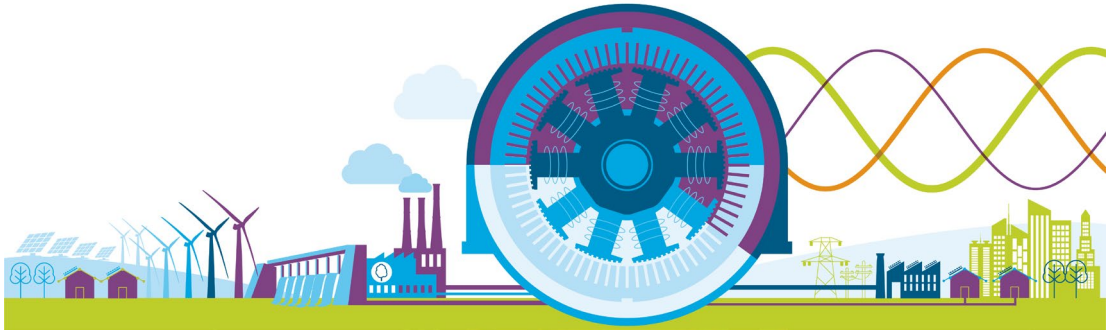
High level goal:

Economic dispatch of frequency response (and reserves) to maintain system security as the power system transforms

Meeting objectives:

To discuss the following in relation to the FFR and PFR rule changes.

1. The problem definition and reform objectives
2. The high level policy options and pathways
3. The process for assessment and consultation



3.

INTERACTIONS WITH THE ENERGY SECURITY BOARD POST-2025 MARKET DESIGN

4.
UPDATE ON AEMO'S FREQUENCY CONTROL ACTIVITIES

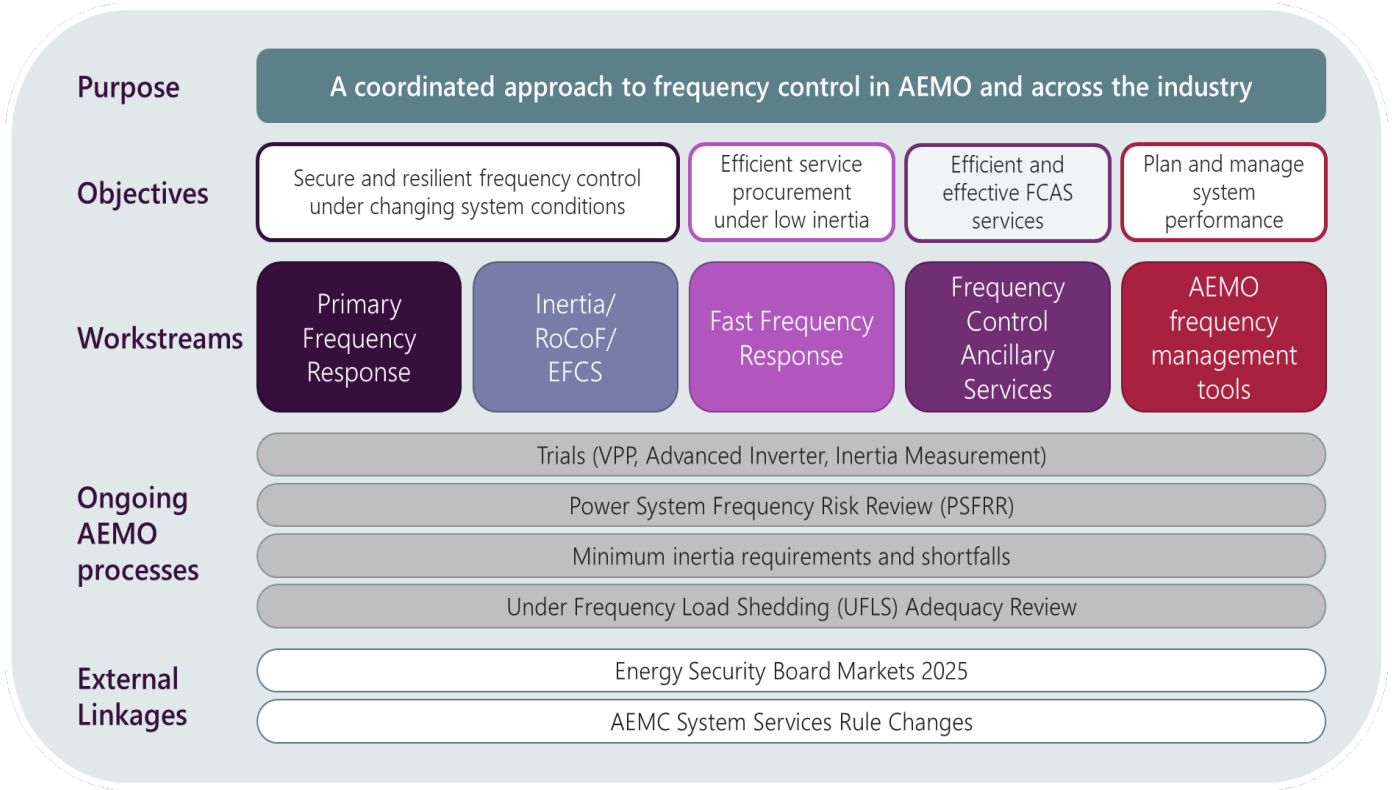
AEMO Frequency Control Work Plan

Purpose

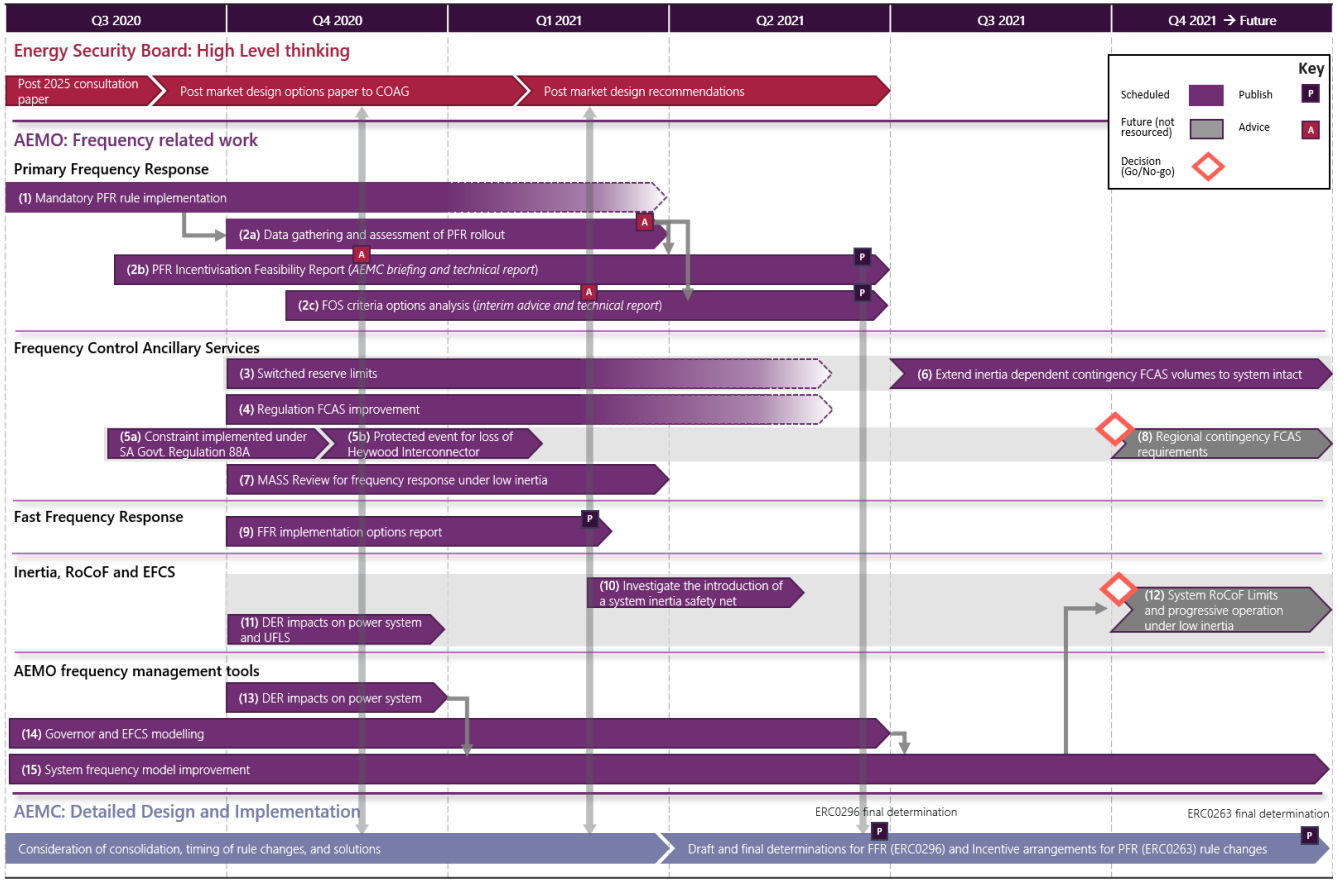
AEMO has recently published a Frequency Control Workplan, with the aim of providing :

- **Visibility** – Improved communication of AEMO's work packages and priorities for frequency control.
- **Coordination** – Coordinate with complimentary initiatives across industry related to frequency control, including the AEMC system services rule changes and the ESB post-2025 market design work.
- **Prioritisation** – Due to the volume of potential frequency control-related work and reforms there is a need for prioritisation.

Frequency Workplan Overview



Frequency Workplan Overview



Intersection with rule changes

- Fast frequency response rule change (ERC0296)
  - FFR Implementation options report (Feb 2021)
  - Identification of the technical 'gap' that FFR can help fill
  - Implementation considerations of FFR options
  - Technical considerations of FFR delivery

- Primary frequency response incentive arrangements rule change request (ERC0263).
  - Technical input on PFR Incentivisation Rule Change (June 2021)
  - Frequency Operating Standard (FOS) Criteria Options Analysis (June 2021)
  - Make use of the learnings of MPFR roll out to inform rule change
  - High level review of incentivisation options (technical consideration, practical implementation considerations).
  - Investigation into the feasibility of changes to causer pays to further incentivise PFR

More information / Feedback

Frequency Control Workplan:

https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/system-operations/ancillary-services/frequency-control-work-plan

For any questions or comments regarding the AEMO frequency control work plan, please contact FutureEnergy@aemo.com.au.

AEMO PFR Roll-out

8 Oct 2020 update

Progress

AEMO is continuing to work to achieve implementation of PFR Settings across the largest possible proportion of Tranche 1 Affected GSs prior to Summer 2020-21.

To date:

- 72 completed Tranche-1 self-assessments
- 8 completed Tranche 2 & 3 self-assessments
- 18 Tranche 1 applications for variation (14 granted to date)
- 8 Tranche 1 applications for exemption (none granted to date)
- ~9.2 GW of plant with partial or full implementation of PFR settings (~6.8 GW of baseload)
- Additional ~10.3 GW of plant scheduled by early Nov 20 (~8.5 GW baseload)

Impact on Frequency Performance

Figure 1 Monthly frequency distribution (six-month rolling, 01 Apr 2020 to 04 Oct 2020)

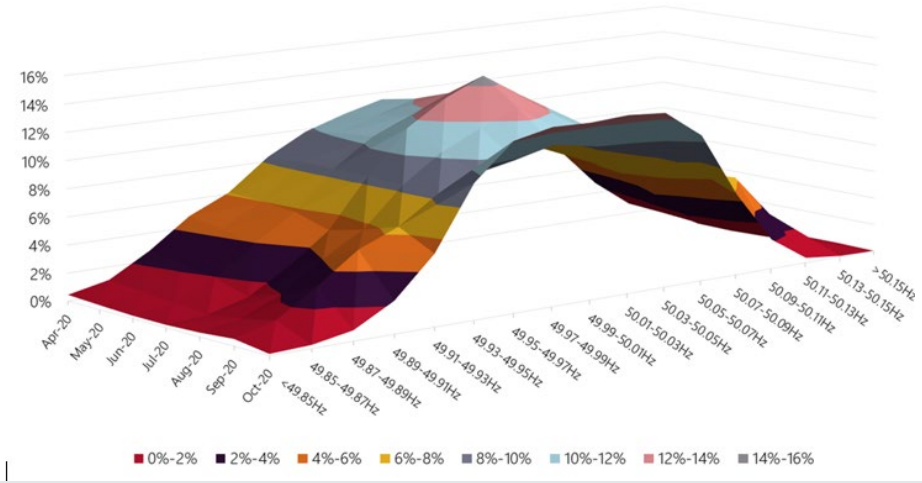
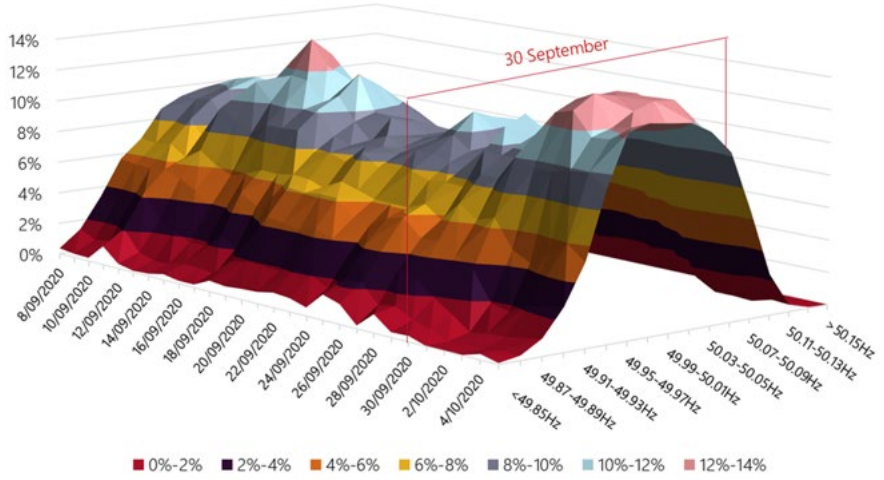


Figure 2 Daily frequency distribution (08 Sep 2020 to 04 Oct 2020)



Impact on Frequency Performance

Figure 3 Monthly frequency crossings – under 49.85 Hz, across 50 Hz, beyond 50.15 Hz

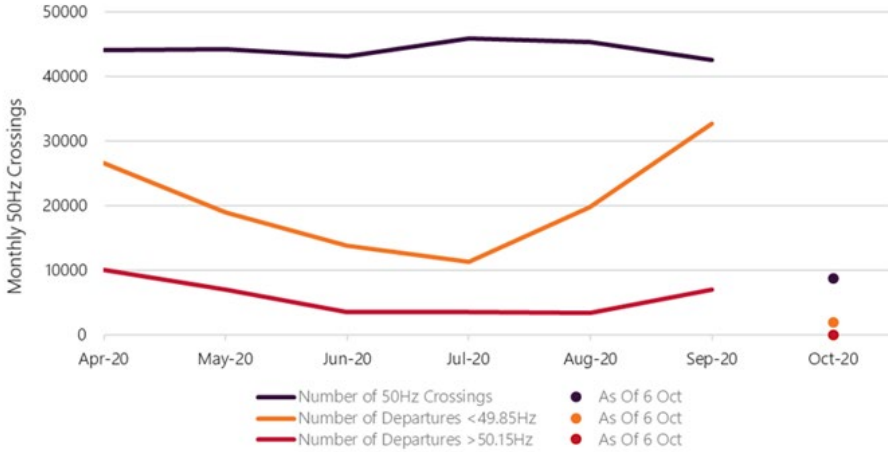
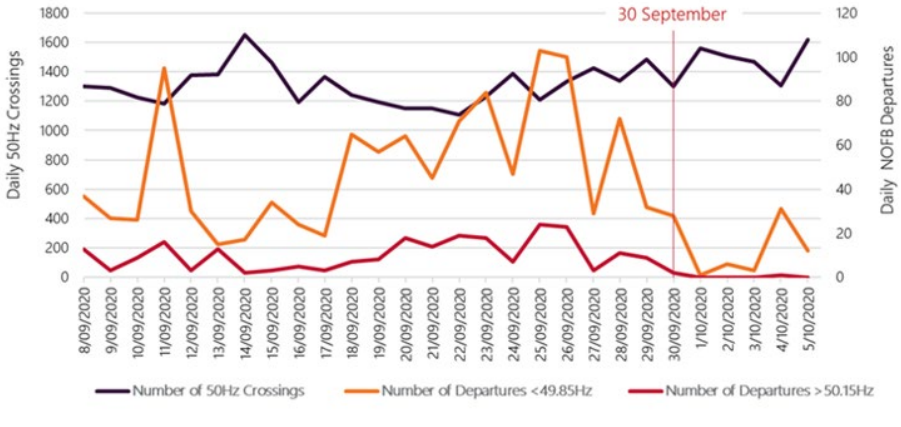
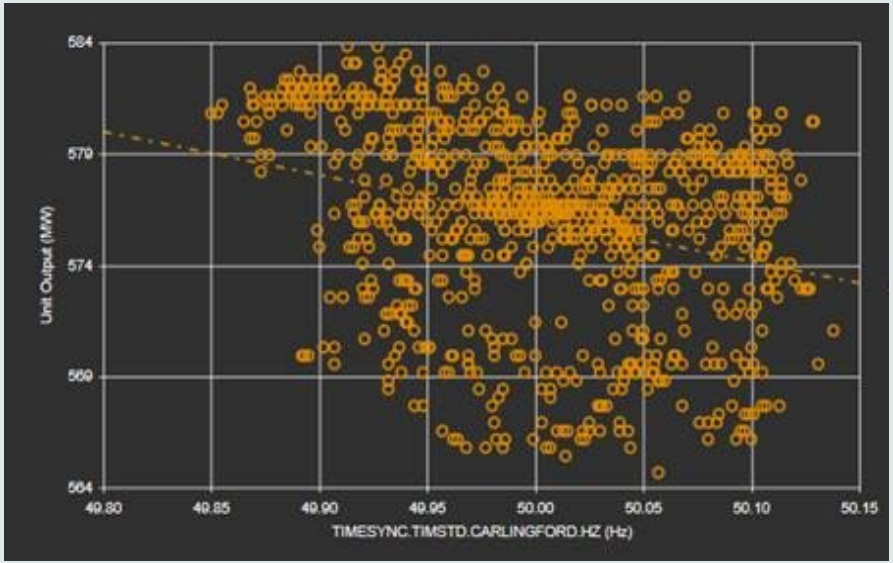


Figure 4 Daily frequency crossings – under 49.85 Hz, across 50 Hz, beyond 50.15 Hz

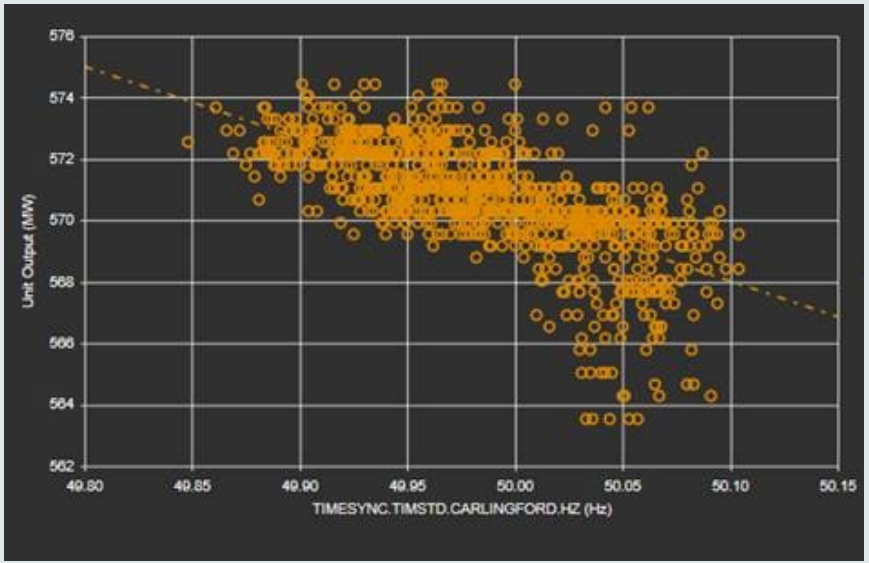


Example – Large thermal plant

Pre-implementation



Post-implementation



More information

PFR Information:

https://aemo.com.au/en/initiatives/major-programs/primary-frequency-response

For any questions regarding PFR, please contact pfr@aemo.com.au

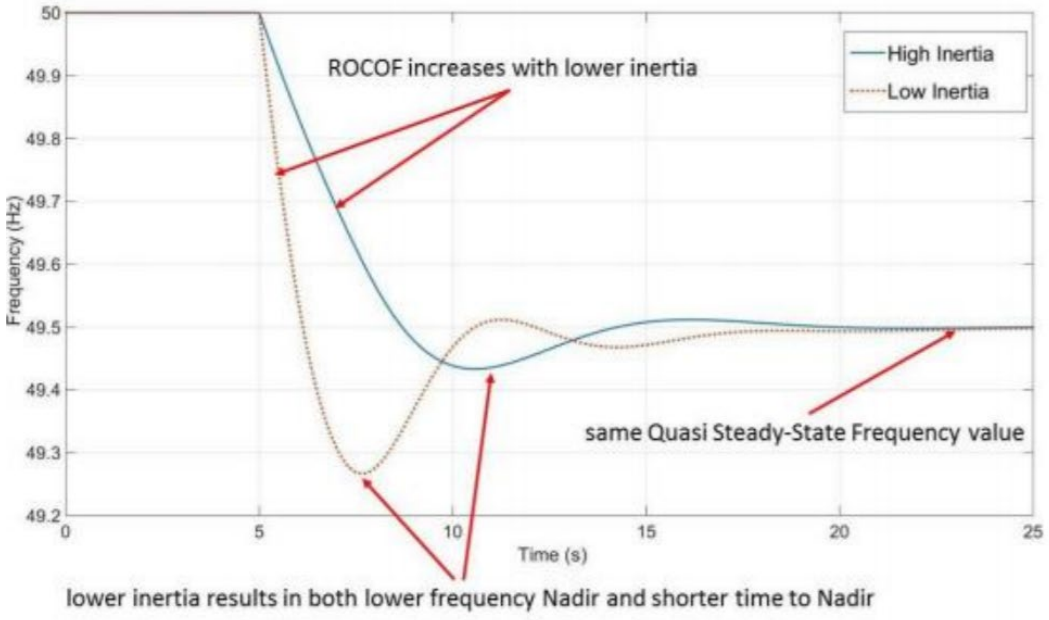
5.
FAST FREQUENCY RESPONSE MARKET ANCILLARY SERVICE

5.1 Fast frequency response - Problem definition, Infigen's rule change request

In its rule change request, *Fast frequency response market ancillary service,* Infigen identified that the displacement of synchronous thermal generators by inverter-based generation is causing a reduction in power system inertia which in turn leads to:

- An **increase in the instantaneous Rate of change of frequency** (RoCoF) following contingency events, which can undermine the effectiveness of existing protection systems including FCAS and under-frequency load shedding
- In the absence of faster responding reserves this may lead to **an increased requirement for 6 second contingency FCAS** to arrest the frequency in accordance with the contingency containment band in the frequency operation standard.

Infigen note that faster acting response can help mitigate the requirement for increased 6 second reserve during low inertia operation.



"AEMO does not currently appear to have the ability to procure fast-acting services in shorter time frames"

5.2.1 Fast frequency response - Problem definition

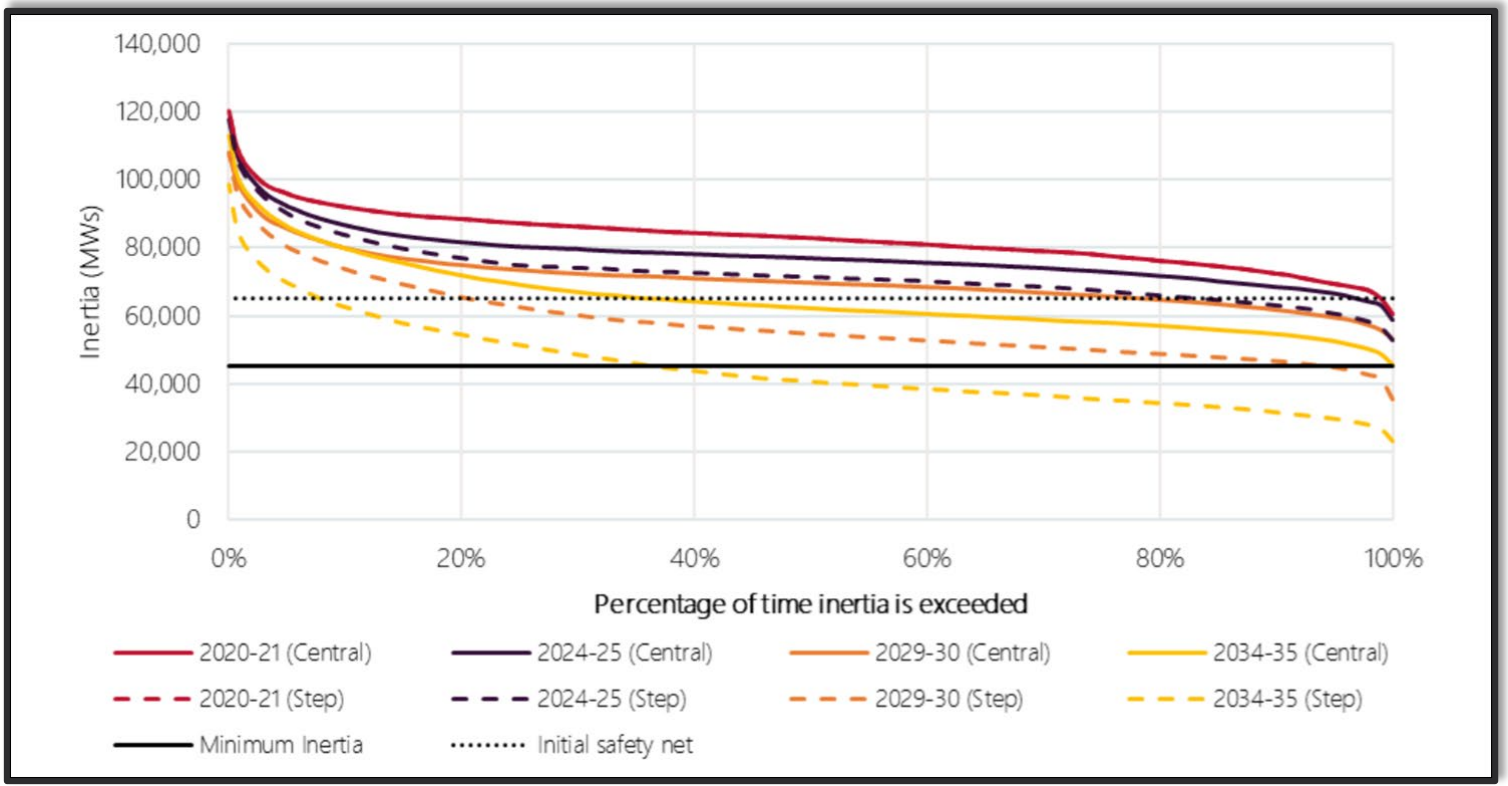
Recently published analysis by AEMO helps to further describe the problems related to operating the NEM in the absence of arrangements to provide for Fast frequency response.

- AEMO's 2020 Integrated system plan (ISP) forecasts declining system inertia levels out to 2035
- AEMO's stage 1 report for its Renewable integration study (RIS) shows that for low inertia system operation in the absence of FFR, the procurement of fast contingency services (R6/L6) will become increasingly inefficient.
- Provision of faster responding frequency reserves can mitigate the requirement for increased R6/L6 reserves.

5.2.2 Fast frequency response - Problem definition – system inertia is decreasing

System inertia has been decreasing in recent years and this trend is expected to continue.

Historic and forecast inertia duration curves for mainland NEM

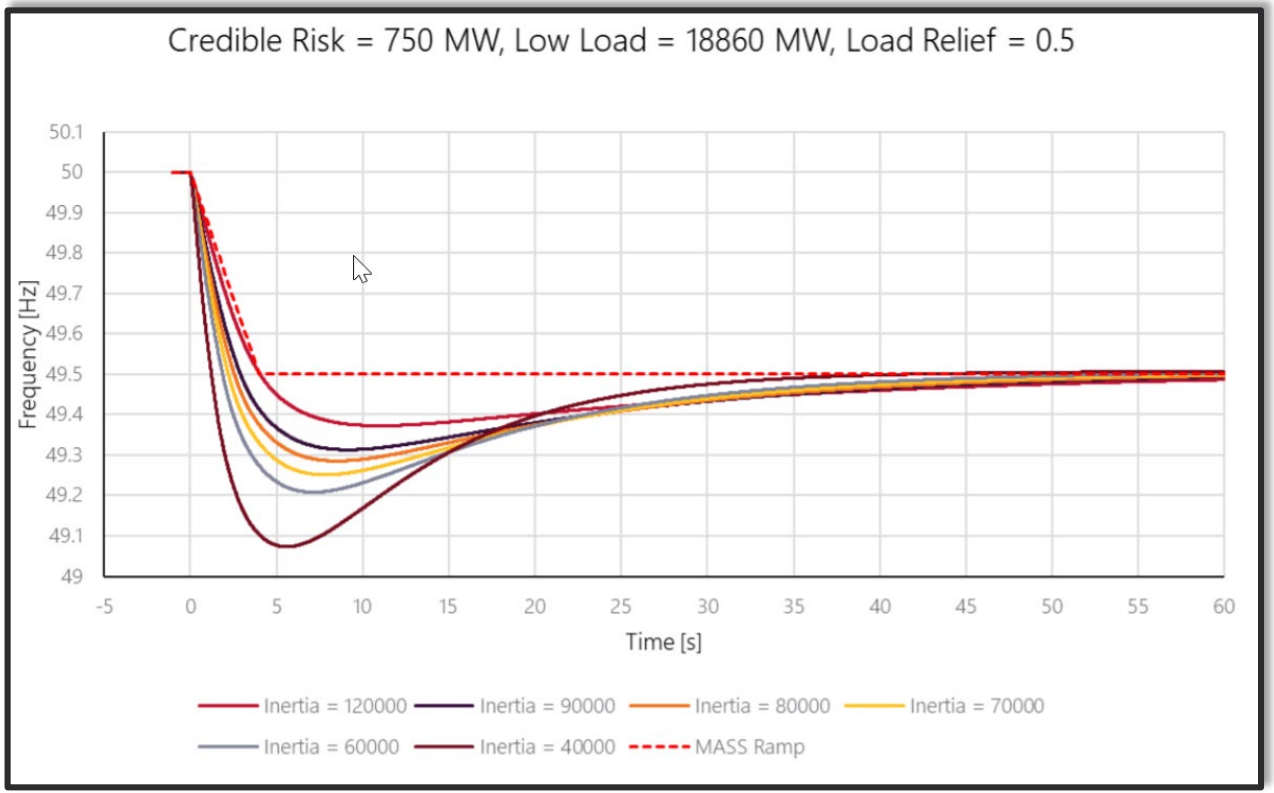


Ref. AEMO, 2020 Integrated system plan – Appendix 7 – Future power system security, 30 July 2020, p.38.

5.2.3 Fast frequency response - Problem definition – frequency nadir

System inertia helps to mitigate the depth of the frequency nadir following contingency events. Assuming other factors are kept constant – (reserve volume, speed of response, system load, load relief)

Impact of decreased system inertia on frequency nadir



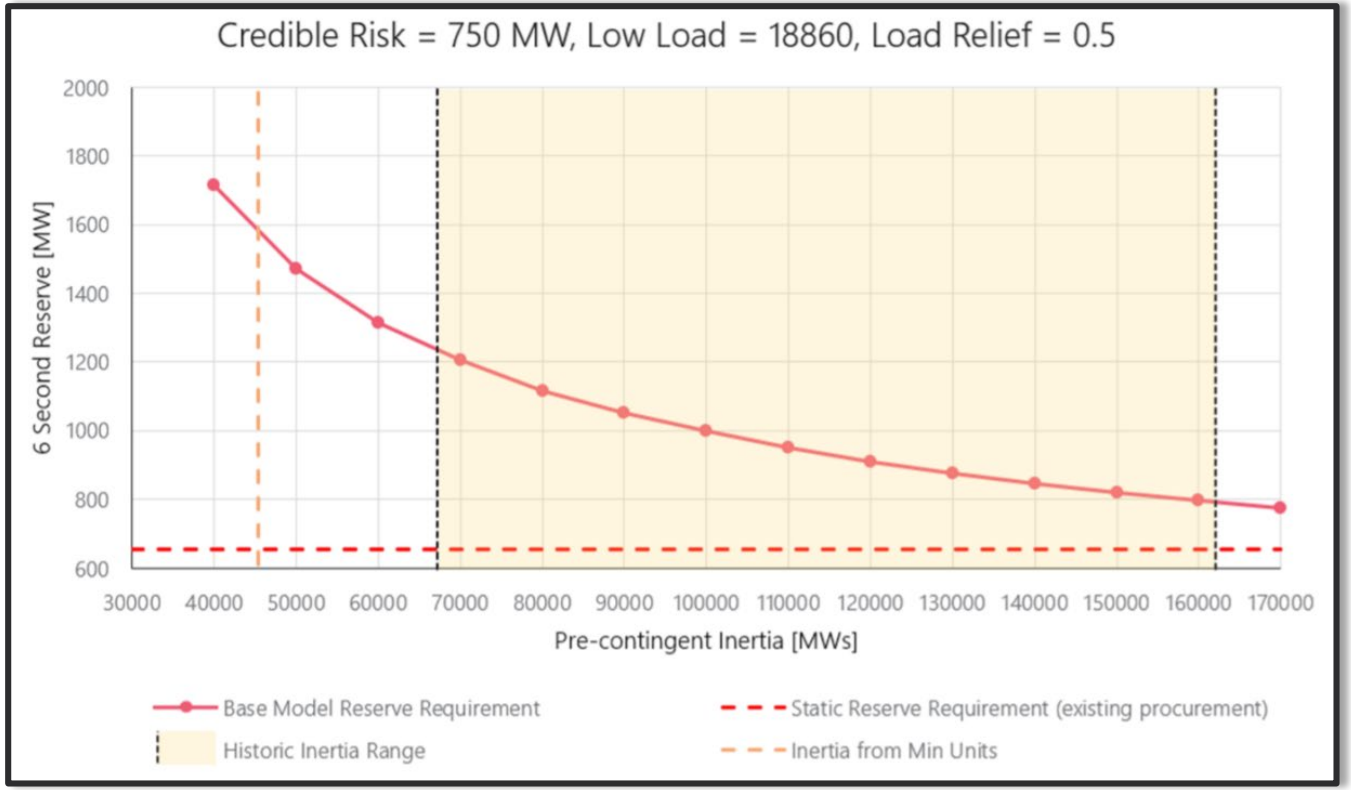
Ref. AEMO, Renewable integration study – Stage 1 report - Appendix B; Frequency control, March 2020, p.24.

5.2.4 Fast frequency response – requirement for 6 second raise service vs inertia

The requirement for "fast" raise 6 services increases as system inertia decreases.

Note. – AEMO intend to extend inertia dependent constraints for contingency FCAS volumes in Q3/Q4 2021. (AEMO, Frequency control work plan, 25 September 2020, p.11.)

6 second raise reserves Vs system inertia



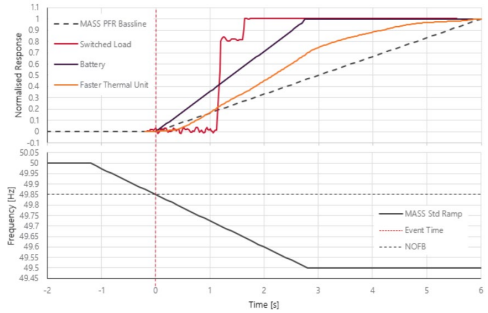
Ref. AEMO, *Renewable integration study – Stage 1 report* , March 2020, p.46.

5.2.5 Fast frequency response – impact of faster R6 on R6 requirement

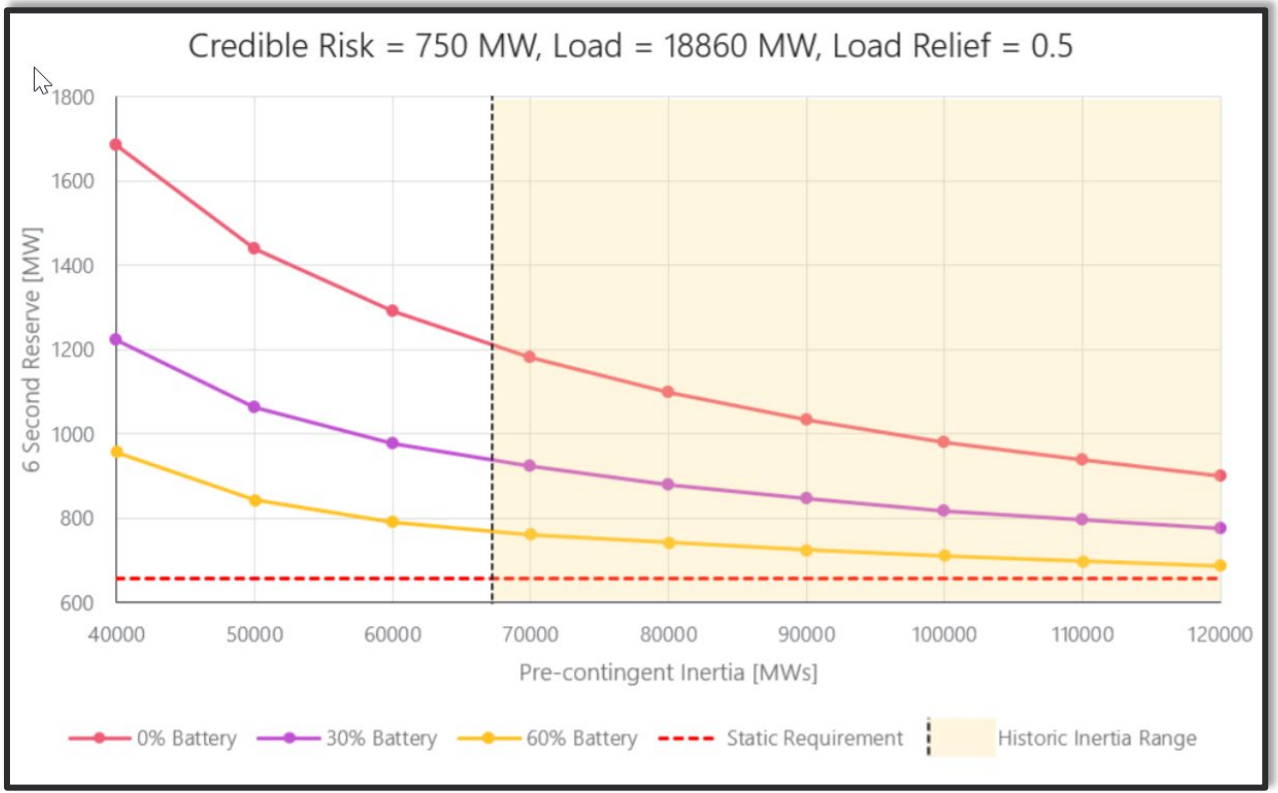
Faster response is effective at reducing the volume of frequency sensitive reserves required for secure operation with reduced system inertia.

However, AEMO notes that increased use of these technologies will require further investigation of the broader system impacts.

RIS model - responses to standard frequency ramp



Impact of FFR from battery energy storage on 6 second raise requirement



Ref. AEMO, Renewable integration study – Stage 1 report, March 2020, p.47.

5.2.6. Fast frequency response – Problem definition and reform objectives

The Commission proposes a refined problem statement for this rule change request to guide the assessment process.

The **problem statement** is restated as:

i. The existing market and regulatory arrangements do not explicitly provide for effective utilisation of Fast frequency response to control system frequency at the lowest cost.

ii. This constitutes a missing market and does not provide adequate price signals to support efficient investment in the equipment needed for future power system operation

iii. This is particularly the case for system intact operation and is expected to drive increasingly inefficient market outcomes as system inertia levels decline over the coming years.

The **reform objective** for FFR is:

To develop market arrangements that facilitate the provision of Fast frequency response to support the economic dispatch of energy and ancillary services in the NEM.

QUESTION FOR DISCUSSION:
Do working group participants agree with the characterization of the problem statement and reform objective for FFR?

5.3. Fast frequency response - Economic and technical analysis

The Commission plan to undertake economic analysis and work with AEMO to understand how FFR interacts with other frequency control services and the potential costs of maintaining the existing arrangements.

This will help inform the timing for the implementation of an FFR arrangement in the NEM.

1. Economic analysis – cost of inaction (December 2020)

The AEMC plan to undertake economic analysis based on available information to estimate the materiality associated with operating the NEM in the absence of FFR to inform the policy design of different FFR options. Results to be published in the directions paper in December 2020.

OBJECTIVE: Investigate the economic costs of maintaining current FCAS arrangements without FFR.

OUTPUT: Estimate indicative cost increase for six second raise (R6) under low inertia future.

METHOD:

1. Determine future R6 required as a function of inertia, largest credible risk (LCR), and system demand using AEMO's RIS modelling and ISP model projections.
2. Use inertia duration curve to estimate increased R6 requirement to manage reduced inertia without FFR.
3. Comment on indicative increased R6 costs based on historical FCAS costs.

Note: this will ignore any correlation between system inertia levels and FCAS costs.

2. AEMO advice – interaction between FFR, inertia and FCAS

AEMO have committed to provide advice in February 2021 to inform the development of a draft determination for the FFR rule change. The **preliminary scope** for this advice includes:

- Describing the interactions between inertia and FFR for system intact operation
- Investigation of operational considerations and limitations for FFR.
- Estimate of current and future available FFR capacity
- Modelling of how FFR FCAS would interact with existing FCAS

The scope of this advice is still under development and will be confirmed by AEMO by late 2020 for reference and consultation through the in directions paper for the frequency control rule changes.

QUESTION FOR DISCUSSION:

Do working group participants have any feedback on the approach to technical and economic analysis for FFR?

5.4.1. Fast frequency response – Policy options

The Commission have identified the following potential FFR pathways for further development and stakeholder consultation.

1. New FCAS markets for FFR

a) Introduce New FCAS markets : "R2/L2"

- In its rule change request, Infigen propose that new FCAS markets be included to support the procurement of 2 second raise and lower FCAS.
- Under this approach, the NER would be modified to include additional "very fast" contingency reserve market ancillary services and AEMO would revise the MASS to determine the service description and specification for the new services.
- This approach may not require revision of the existing FCAS specifications.

2. Revise existing FCAS markets

a) Strawman 1: R6/L6 → R2/L2

- Re-task the existing fast raise and fast lower services to be FFR services
- This may not require a change to the NER

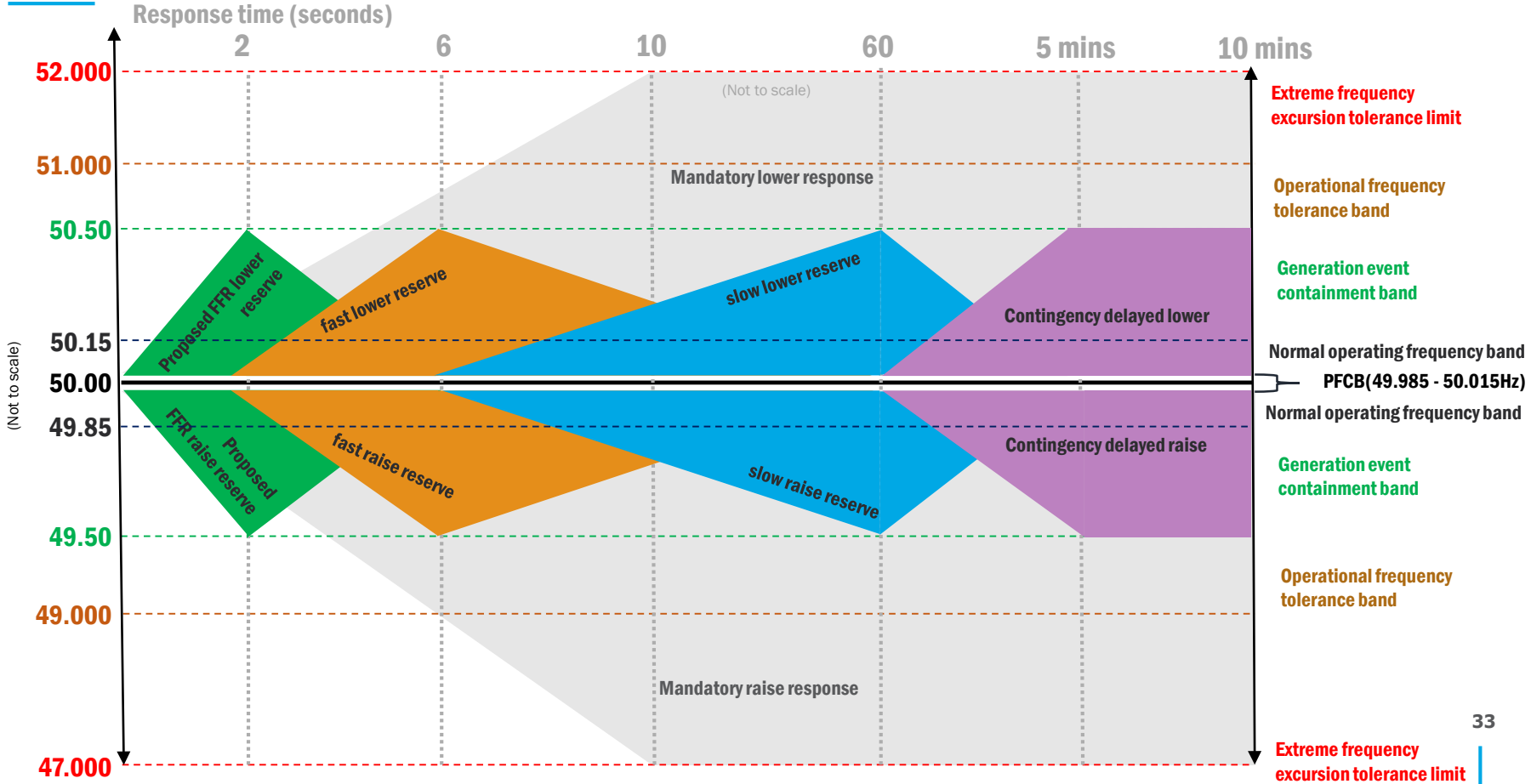
b) Strawman 2: R6/L6 → (R2-6/L2-6)

- Incorporate FFR within the existing fast raise and fast lower services
- This may be supported through the use of performance multipliers (or similar alternative) to reward faster response and accommodate a range of response speeds within the same ancillary service market.
- The use of performance multipliers would require a change to the NER

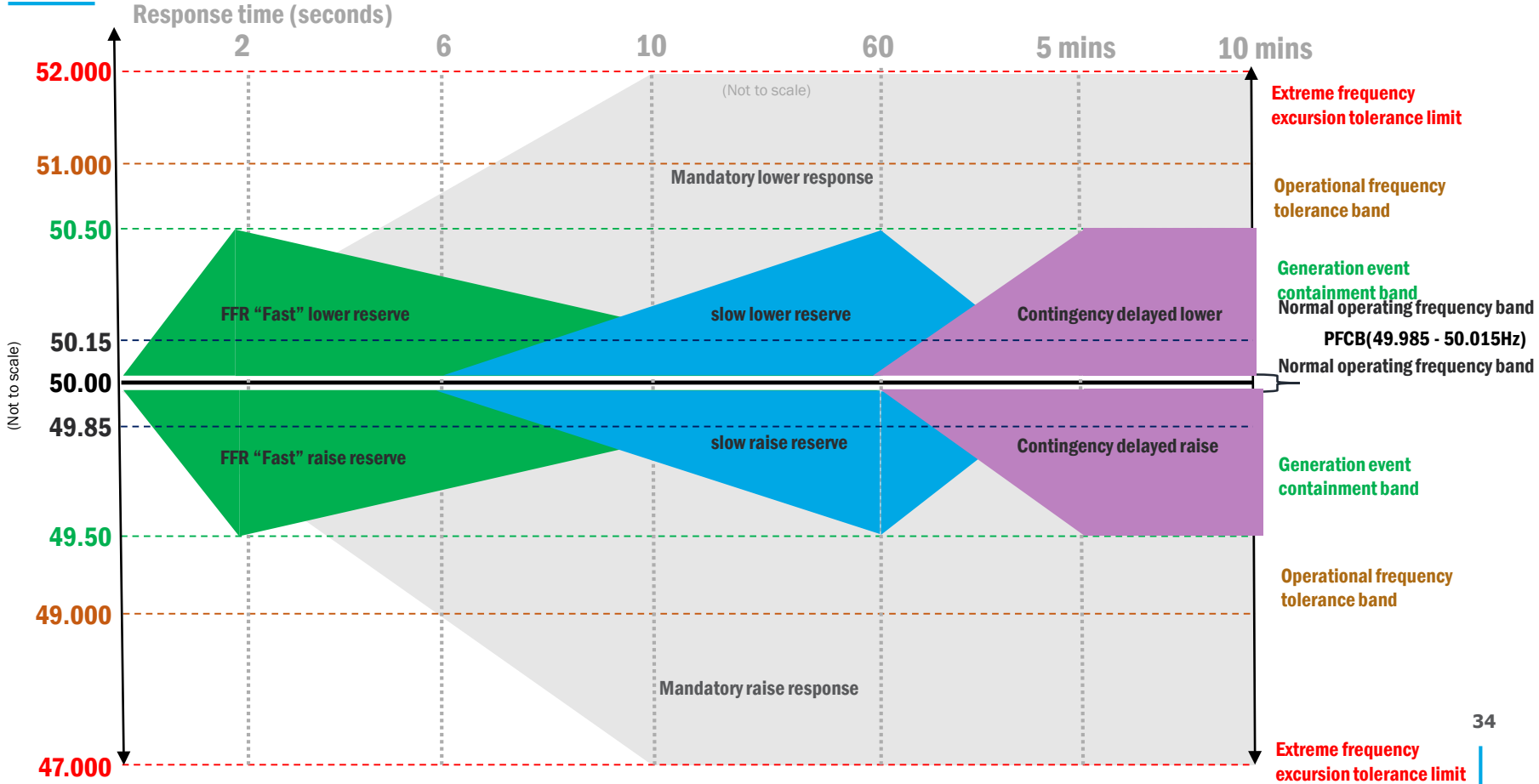
QUESTION FOR DISCUSSION:

- **Do working group participants agree with the characterization of potential policy options for FFR?**
- **Are there any additional options that should be considered?**
- **What are participants views on these FFR policy options?**

5.4.2 Existing Contingency services plus a 2 second FFR service – Infigen's proposal



5.4.3. Existing Contingency services with "Fast" services providing FFR – Strawman 1



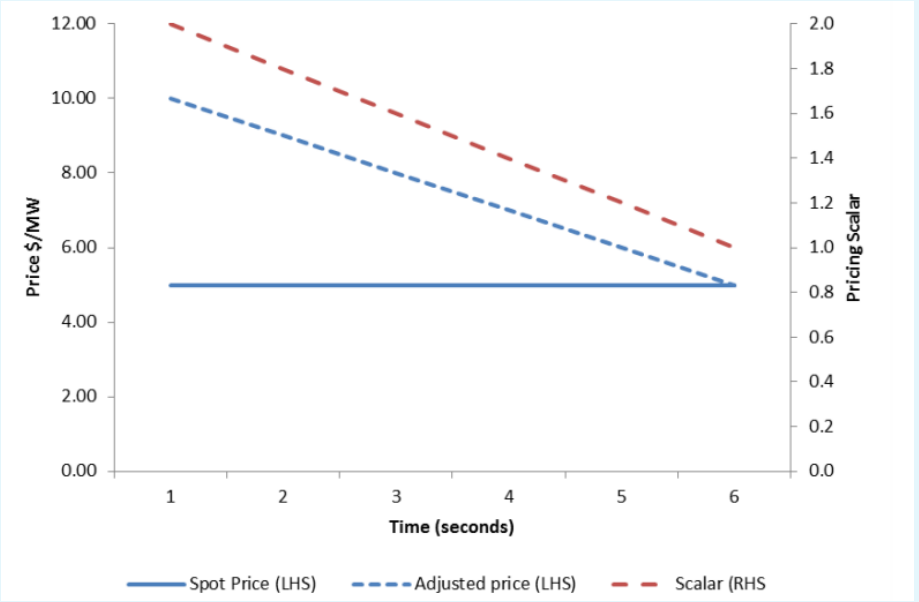
5.4.4 Fast frequency response – differential pricing & scalar multipliers

- In the 2017 *System security market frameworks review*, the Commission considered the potential role of differential pricing for frequency response services based on speed of response.
- Under such a model, contingency FCAS providers that provide a faster active power response would be rewarded with a higher price for their response based on a multiple of the ancillary service market spot price.
- **Eirgrid** use scalar multipliers to reward provision of fast frequency response. These scaling factors can include multipliers based on:
  - Performance (including speed of response)
  - Product characteristics
  - Location
  - Scarcity
- In **Western Australia**, AEMO is developing a system to implement performance multipliers as part of a reformed approach to frequency control services in the WA wholesale electricity market(WEM). (Further detail in appendix)

QUESTIONS FOR DISCUSSION:

What are participants' views on the use of price multipliers in the NEM to reward provision of FFR?

Figure: Application of time weighted scalar to FCAS prices



5.5.1 Fast frequency response - Issues for consideration and discussion

Scope of FFR policy development

- The focus of this rule change request is the development of arrangements to provide for FFR to help manage low inertia operation of the power system.
- This approach is based on the understanding that inertia is a separate power system variable that requires a separate regulatory arrangement.
- The Commission notes that separate arrangements for valuation of inertia are being considered through the ESB essential system services MDI.
- The Commission will consult further with stakeholders on how an FFR arrangement may interact with existing and future arrangements for inertia and whether inertial response should be valued (implicitly or explicitly) through an FFR arrangement.

QUESTIONS FOR DISCUSSION:

Do working group participants agree with the proposed focus of this rule change on development of FFR arrangements?

Interactions with existing and future frequency control arrangements

- How would FFR interact with the other frequency control services, including existing FCAS and potential future PFR arrangements?
- How would an FFR market/mechanism operate for islanded operation of an inertia sub-network/region?
- How would an FFR market/mechanism interact with a potential future arrangement for provision of inertia?

5.5.2 Fast frequency response - Issues for consideration and discussion

Implementation and staging

- AEMO has indicated that there are likely to be some operational challenges associated with implementation of a new or revised FFR arrangement. We will need to understand these challenges and consider transitional arrangements to manage them.
- The Commission will seek to understand the nature of these operational challenges and develop appropriate transitional arrangements to support the smooth implementation of FFR arrangements in the NEM.

Cost allocation

- The existing cost recovery arrangements for contingency services are:
  - For each dispatch interval, costs from contingency raises services are recovered from Market Generators or Market Small Generation Aggregators in proportion to the energy generated by the relevant Market Participants.
  - For each dispatch interval, costs from contingency lower services are recovered from Market Customers in proportion to the energy consumed.

QUESTIONS FOR DISCUSSION:

What are working group participants' views on the challenges associated with

i) implementing a new FFR market ancillary service?

ii) revising the existing FCAS arrangements to include FFR?

QUESTIONS FOR DISCUSSION:

Are the existing cost allocation arrangements for contingency FCAS appropriate for allocating costs from a new or revised FFR service?

6.
PRIMARY FREQUENCY RESPONSE INCENTIVE ARRANGEMENTS

6.1 Primary frequency response – Overview and Context

AEMO's rule change request identified that power system frequency performance during normal operation had degraded in recent years due to:

- a decline in the provision of narrow band PFR by Generators in the NEM
- an increase in the variability of generation and load, partly due to increased level of variable renewable generation
- the inappropriateness of regulation FCAS to effectively control frequency close to 50Hz in the absence of sufficient complementary PFR

The Mandatory PFR rule (March 2020) solves the immediate system security need identified by AEMO in 2019 for near-universal PFR across the NEM to provide consistent active power control.

However,

> The mandatory PFR arrangements on their own are not considered to be a complete solution as they do not allow for adequate valuation of frequency response provided outside of participant enablement for provision of regulation and contingency FCAS.

In the consultation paper for the system services rule changes (July 2020), the Commission indicated that the directions and objectives for this rule change would include consideration of:

- the arrangements for allocation of costs associated with regulation services — 'causer pays'
- the potential development of additional complementary measures to effectively remunerate providers of PFR
- interaction with the arrangements in the Mandatory PFR, including the sunset arrangements.

6.2 Primary frequency response – Problem statement & reform objectives

The Commission propose a refined problem statement for this rule change request to guide the assessment process.

We propose that the **problem statement** is restated as:

- Continuous narrow band PFR is required to complement secondary (regulation) services and control power system frequency during normal operation.
- From 4 June 2023, the NER will not provide for PFR outside of that enabled through the market ancillary service arrangements for contingency reserves
- On its own, the mandatory PFR arrangement is not a complete PFR solution as it does not appropriately value the provision of frequency response provided outside of that enabled through the market ancillary service arrangements for regulation and contingency reserves. This under-valuation of PFR does not support efficient allocation of resources in the NEM and weakens the signals for efficient investment in power system plant to meet future power system needs.
- Therefore, there is a need to develop an enduring arrangement for PFR that meets the operational needs and supports economic operation and investment in the NEM.

We propose that the **reform objectives** for PFR in the NEM be defined as:

The development of complete PFR arrangements that will endure beyond the sunset date, 4 June 2023.

This includes the following actions:

1. Confirm the role of Mandatory PFR
2. Develop additional mechanisms as required to provide sufficient PFR to control system frequency during normal operation.
3. Consider complementary reforms to the existing arrangements for the allocation of regulation FCAS costs – Causer pays.

QUESTION FOR DISCUSSION:
Do working group participants agree with the characterization of the problem statement and reform objective for PFR?

6.3. Primary frequency response – AEMO technical advice

The Commission plan to work with AEMO to understand the system and plant impacts of the Mandatory PFR arrangement and inform the development of enduring PFR arrangements.

AEMO has committed to provide advice by June 2021 to inform the AEMC's draft determination for the PFR rule change in September 2021.

AEMO has identified that this advice will include:

- Commentary on the feasibility of potential PFR arrangements, identified by the AEMC through the directions paper
- Findings from AEMO's plant and system monitoring as part of the implementation of the Mandatory PFR arrangement, this includes
  - Analysis of how the mandatory PFR arrangement impacts generation plant based on measurement of active power variation relative to local frequency, at power station terminals.
  - Analysis of power system impacts, including how the mandatory PFR arrangement impacts power system frequency performance.
- AEMO's views on the need to change the frequency operating standard for system frequency performance during normal operation

QUESTION FOR DISCUSSION:

Do working group participants have any feedback on the proposed technical advice for PFR?

6.4.1 Primary frequency response – reform pathways - key questions

There is a need to confirm the arrangements for PFR that will endure beyond the sunset date, 4 June 2023.

The following questions will help guide the development of complete and enduring PFR arrangements:

1. Is there an enduring role for a mandatory PFR requirement in the NEM? (What happens after 4 June 2023?)
2. Is there a need to procure additional reserves to provide continuous narrow band PFR in the NEM?
3. In the absence of a new continuous PFR service, are the existing incentives arrangements for PFR sufficient and appropriate?
4. Is there a need to change how the required frequency performance for the power system during normal operation is specified in the frequency operating standard?

6.4.2. Primary frequency response — Reform pathways – role of mandatory PFR

Some form of Mandatory PFR may be appropriate as part of a complete PFR arrangement.

The rationale for this is:

- A mandatory PFR requirement at a wider frequency response band provides a valuable system safety net by requiring full utilisation of responsive capacity to respond to non-credible contingency events and help avoid load shedding and black system.
- The degree of economic inefficiency associated with a mandatory PFR arrangement will be proportional to the narrowness of the generator frequency response band. A wider frequency response band will result in reduced distortionary economic impacts associated with under-pricing of PFR.

QUESTION FOR DISCUSSION:

What are working group participants views on the role of mandatory PFR (in some form) as part of enduring arrangements?

6.4.3. Primary frequency response – Reform pathways

Mandatory PFR variation	Is a new arrangement required to procure additional responsive reserves?	Is there a need to improve the pricing arrangements?	General notes
1. Narrow PFCB **(50 ± 0.015Hz - current setting)**	➢ **No** • The existing FCAS markets provide a mechanism to purchase responsive reserves. AEMO can vary these reserve volumes to operate the system securely and meet the FOS. • All plant is required to respond outside of the narrow response band, therefore it will be difficult to differentiate a continuous PFR service from the existing contingency services.	➢ **Yes** • The narrow mandatory arrangement drives response from generators beyond that procured through the FCAS markets, therefore some response is likely to be un-priced and there is likely to be an economic benefit in some form of PFR incentive reform that values this.	• This option was recommended by AEMO's technical advice for the mandatory PFR rule change. • This option is expected to improve frequency control during normal operation and system resilience to non-credible events • This option degrades the economic efficiency of the frequency control frameworks and is not a complete solution.
2. Moderate PFCB - (~±0.15Hz)	➢ **Yes** • An additional system service mechanism would be required to provide sufficient PFR for continuous frequency regulation and to complement the existing regulation service. • Such a 'Primary regulating service" would provide AEMO with additional tools to set the volume of continuous PFR required in the NEM,(on a regional basis as required) and allow for optimization with other system services, including standard regulation services, FFR, inertia and contingency	➢ **Maybe** • If a new Primary regulating service was established, un-priced provision of PFR would be confined to provision of mandatory contingency response that is not enabled through the FCAS markets.	• This option is expected to deliver improved system resilience. • Additional complementary arrangements may be required to provide continuous primary response during normal operation. • Technical investigations required to validate this approach to power system operation
3. Wide PFCB **(~±0.5Hz)**		➢ **no** • With such a wide PFCB, un-priced provision of PFR would be extremely rare.	• AEMO has previously indicated that this approach could lead to degraded frequency control.
4. none		N/A – generators not required to provide PFR unless enabled to do so.	• This path does not supporting consistent active power control and system resilience.

6.4.4. Primary frequency response – Reform pathways

The Commission have identified three pathways for the development of enduring PFR arrangements for the NEM.

1. Maintain the existing Mandatory PFR arrangement with improved arrangements to price PFR

This pathway involves the continuation of the existing Mandatory PFR requirement including the narrow response band very close to 50Hz (±0.015Hz).

Frequency responsive reserves

AEMO would continue to procure frequency responsive reserves through the existing FCAS arrangements.

In effect, the procurement of contingency reserves would also provide reserves for continuous PFR to help control system frequency during normal operation.

Pricing and incentive arrangements

Under this approach, there is expected to be a material provision of PFR outside of that enabled through the FCAS arrangements. Complementary pricing arrangements would be developed to reflect the value provided by this response and send a price signal to support efficient investment decisions. This could be through double sided causer pays or some other arrangement.

2. Revise the Mandatory PFR arrangement and develop new market ancillary service for PFR

This pathway involves the continuation of the existing Mandatory PFR requirement in a revised form along with the development of a new complementary arrangement to procure reserves for provision of continuous PFR.

The PFCB would need to be widened to make room for the new continuous PFR service. Options for a wider PFCB include:

1. A moderate setting close to the Normal operating frequency band - (50 Hz ±0.15Hz)
2. A wide setting close to the contingency containment band (50 Hz ±0.5Hz)

The PFCB could be revised by the AEMC and may subsequently be reviewed by the Reliability Panel as part of a review of the FOS.

3. Replace Mandatory PFR with alternative

Under this pathway, the mandatory PFR arrangement would be allowed to lapse on 4 June 2023.

Alternative arrangements would be developed to provide effective frequency control during normal operation and increased resilience following non-credible contingency events.

QUESTION FOR DISCUSSION:

Do working group participants agree with the characterization of potential policy pathways for enduring PFR arrangements? Are there any other options?

6.5 Primary frequency response - future FOS review

Future review of the Frequency operating standard (FOS)

- AEMO and the AEMC have identified that a review of the FOS by the Reliability Panel forms part of the forward work plan for frequency control reform in the NEM.
- The review of the FOS is likely to commence following finalisation of related investigations by AEMO and progress by the AEMC on the frequency control rule changes.
- AEMO's advice on the enduring arrangements for PFR will include it's views of how the FOS specifies the operational objectives for frequency management in the power system including the target frequency performance during normal operation.
- AEMO's advice will inform the design of the enduring arrangements for PFR, that the AEMC will develop through the assessment of the *Primary frequency response incentive arrangements* rule change request. It will also inform the scope and objectives for a future review of the FOS by the Reliability Panel.
- The review of the FOS is likely to consider the settings that relate to frequency control during normal operation including:
    - The primary frequency control band (PFCB) - 49.985Hz – 50.015Hz
    - The normal operating frequency band (NOFB) - 49.85Hz – 50.15Hz
    - The normal operating frequency excursion band (NOFEB) - 49.75Hz – 50.25Hz
    - The specification of the frequency distribution during normal operation - 99% within the NOFB

7.
AEC FREQUENCY CONTROL WORKING GROUP BRIEFING

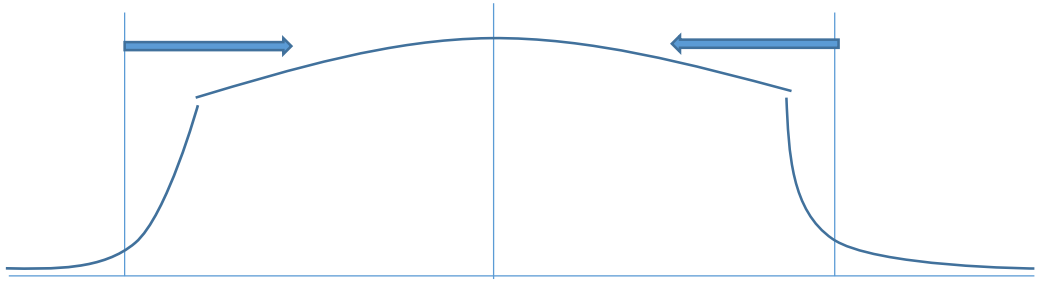
AUSTRALIAN ENERGY COUNCIL

LONG-TERM PRIMARY FREQUENCY RESPONSE
AEC PREFERRED PATHWAYS

AEMC TWG – HZ CONTROL RULE CHANGES 8 OCT 2020

AEC HZ CONTROL SUBGROUP

- Generators meeting regularly discussing current issues
  - Agreed that frequency performance needed rectification
  - Disagreed with mandatory uncompensated PFR
- Want a market arrangement no later than sunset
  - Recommended Reliability Panel update NOFB FOS to empower purchase of more narrow-band frequency services



Our problem: too much choice

- Need to stop driving around in circles pondering perfection
- Subgroup laid out the options and methodically winnowed
- Plus a safe implementation path for acceptability

The options we considered

1. Narrow-band PFR bought via an FCAS enablement market
2. Bringing the Contingency FCAS service activation range in much closer to 50Hz
3. Double-sided Causer-pays
4. Mandatory PFR with regulated payment (Norway)
5. Regulation providers must also deliver Narrow-band PFR

Tested against:

A. Economic efficiency
B. Ease of Implementation
C. Security confidence/acceptability

The Rejects

- Mandatory PFR with Regulated payment
  - Unlikely to find right values or properly discriminate,
  - Surprisingly difficult to do
  - Norway experience poor
- Narrowing Contingency FCAS response band
  - No longer for “contingencies” – activating frequently. How much to buy?
  - Would be difficult for some existing providers – demand-side
- Regulation FCAS obliged to also provide narrow PFR
  - Also exclusionary: some providers can’t do both
  - Quantity allocations – may need to create subdivisions – implementation

First standout: PFR FCAS

- Reliability Panel sets the new NOFB standard
- AEMO determines how much PFR up/down is necessary to retain that.
- Bid FCAS up/down market like all the others: i.e. trapeziums, co-optimized
- Providers must have ±0.015Hz deadbands, standard droop and full headroom equivalent to enablement quantity
  - Performance regularly monitored by AEMO like regulation
- Costs allocated either as per regulation or as per contingency FCAS

Second standout: DSCP

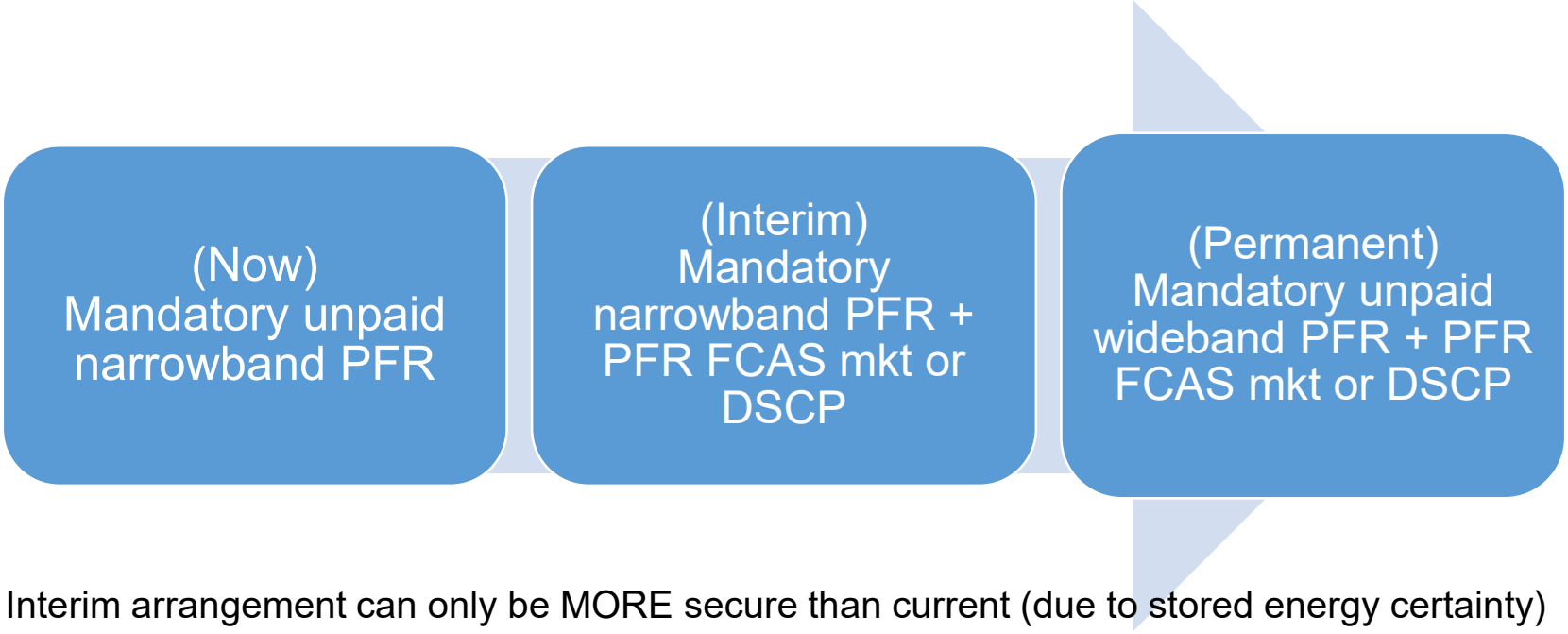
- Like current causer pays but:
  - Bad performers pay good performers
  - Settlements balanced every 4 seconds (no 4-week lag)
  - Pricing function imposed – likely drawn from Regulation market
  - Regulation causer-pays unchanged
- No quantity specification from AEMO: the mechanism self-corrects

$$Scheduled\ Deviation\ Gen = ActualGeneration - TargetTrajectory$$

But what about 25 August 2018s?

- The market-based solutions will deliver a tight normal operating frequency band
  - They procure stored-energy (PFR FCAS explicitly, DSCP indirectly) so they will do this better than the mandatory rule….
    BUT
  - They are not intended for contingencies….especially non-credibles!
- However, non-credible protection was part of AEMO's argument for universal PFR
- Subgroup proposes extending mandatory unpaid PFR on wide-band only, say ±0.500Hz, as safety-net, no stored energy requirement
  - This **is** economically distortionary, but only mildly

Low-risk phase in



Interim arrangement can only be MORE secure than current (due to stored energy certainty)

Interim arrangement costs should be low, but provide incentive to retain post sunset

Double-sided Causer-Pays investigation

- CS Energy sponsored investigation completed April 2020
  - Involved modelling of payment streams to one unit with real 4 second data
- Some uncertainty remains
  - Stability with non-traditional suppliers
  - Likely prices required for global solution
  - Quality of SCADA
- Second report to start shortly
  - Funded by AEC and ARENA grant
  - Interim reports, completing ~April 2021
- Prospects of this solution depend on success of this work

AUSTRALIAN
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8.
CONCLUDING REMARKS AND NEXT STEPS

8.1. Next steps

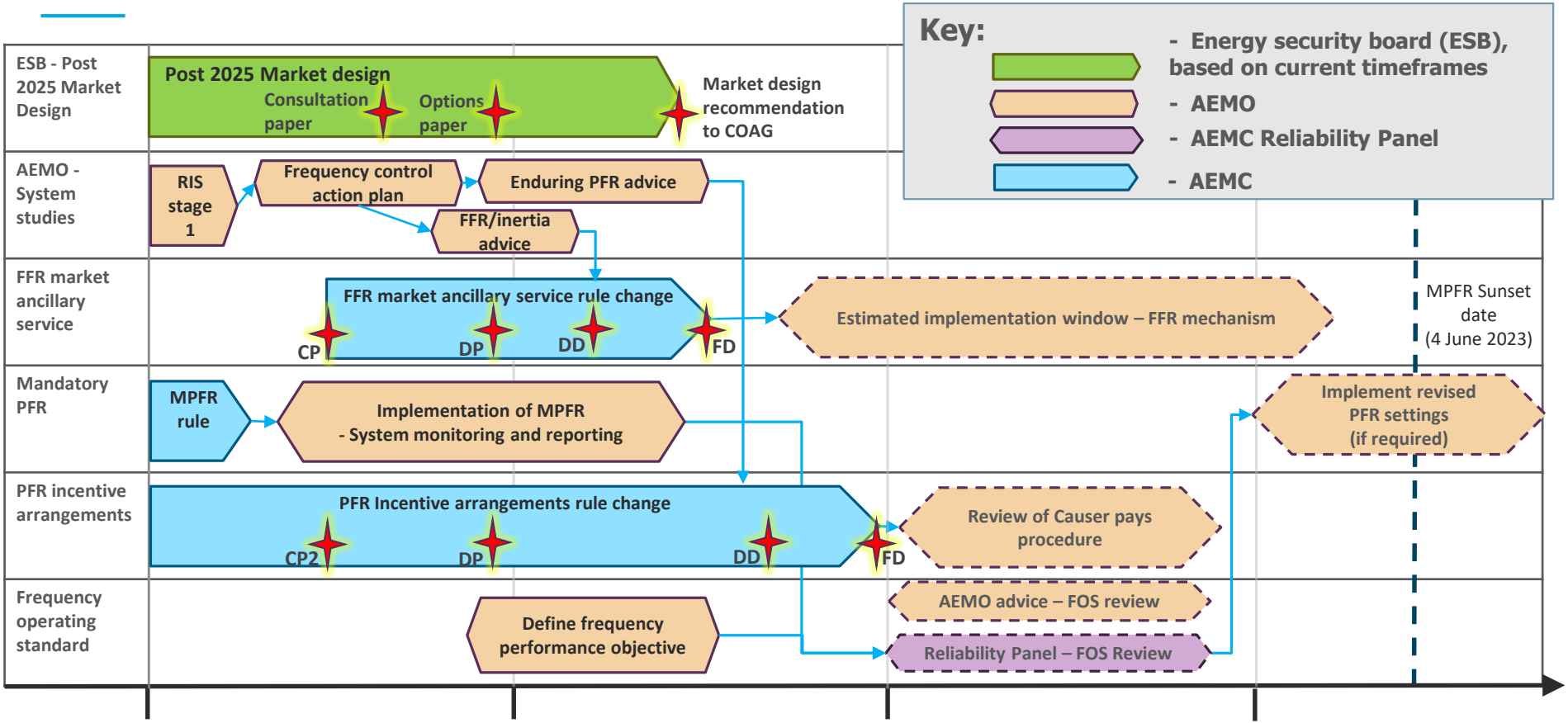
We plan to publish a directions paper to seek stakeholders' views on the policy directions for the frequency control rule changes. Timing TBC.

The AEMC will publish a draft determination for the FFR rule change by 22 April 2021.

The AEMC will publish a draft determination for the PFR rule change by 16 September 2021.

The AEMC intends to schedule a technical working group in early 2021 to continue discussing issues related to the development of market ancillary service arrangements for FFR. Dates to be confirmed.

8.2 Overview of the frequency control work program

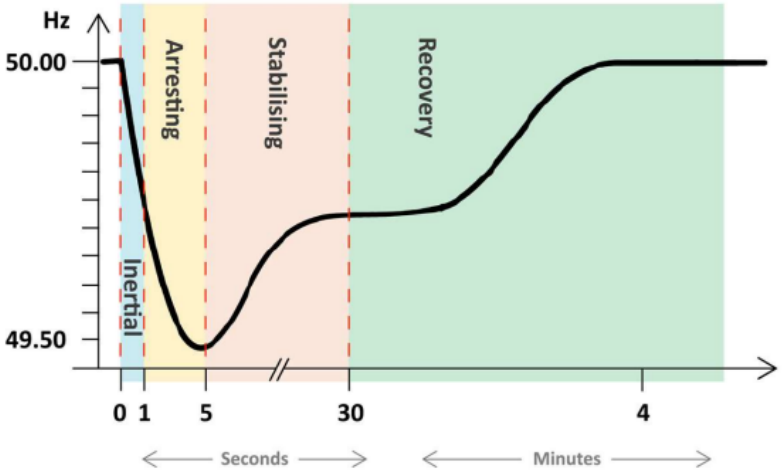


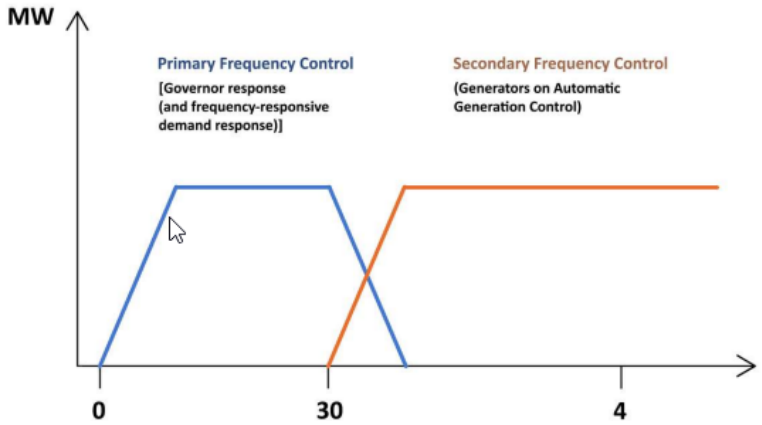
APPENDIX

FURTHER INFORMATION RELATED TO FREQUENCY CONTROL

A.1 What is primary frequency response?

- Primary frequency response (PFR) is an automatic change in active power provided by a generator (or withdrawn from a load) in response to the locally measured power system frequency.
- In the NEM PFR is required to be provided by market participants who are enabled to provide the fast, slow and delayed services.
- Secondary frequency control restores frequency to normal operating levels through coordination of centralised and local control systems. In the NEM secondary frequency control is provided by regulating services and controlled by AEMO's automatic generation control system (AGC).
- Effective frequency control during normal operation requires the coordinated delivery of primary and secondary frequency control.





Ref. AEMO, Final Report – Queensland and South Australia system separation on 25 August 2018, 10 January 2019

A.2 Primary frequency response and the current frequency control arrangements

- **Primary frequency response** (PFR) is a system service that reacts automatically and almost instantaneously to locally measured changes in system frequency outside pre-determined set points. PFR involves an automatic change in active power generated (or consumed) by a generator (or load) in response to a locally measured change in system frequency.
- The NER provide for PFR through the mandatory PFR arrangements and the arrangements for FCAS.
- The **Mandatory PFR arrangements** include:
  - All scheduled and semi-scheduled generators must provide PFR when dispatched to >0MW
  - AEMO specifies the performance parameters for mandatory PFR in the *Primary frequency response requirements*(PFRR)
  - AEMO must define the maximum allowable deadbands to apply to generators under the PFRR, these deadbands may not be narrower than the Primary frequency control band(PFCB), set out in the NER.
  - The PFCB is defined in the NER as 50Hz ±0.015Hz, this band may be revised by the Reliability Panel
  - Generators are not required to maintain additional stored energy to meet the PFRR
- The **FCAS arrangements** include:
  - **Contingency FCAS** (Primary reserves) - AEMO can specify the performance parameters for the six contingency FCAS services in the Market ancillary service specification (MASS) (fast, slow and delayed - raise and lower services). The NER definition for each of these service includes that a facility be capable of controlling its generation or load(active power) in response to the locally sensed frequency of the power system. These services provide frequency responsive reserves to stabilise and restore system frequency following a credible contingency event.
  - **Regulation FCAS** (Secondary reserves) - AEMO can specify the performance parameters for the regulating raise and lower services in the MASS. These services act in response to electronic signals from AEMO's Automatic generation control(AGC) system to raise or lower the frequency of the power system. The typical effective response time for regulation FCAS is in the order of 10 – 30seconds.

A.2.1 Fast frequency response and the existing arrangements

AEMO's 2017 FFR working paper, *Fast frequency response in the NEM*, defined FFR as

"the delivery of a rapid active power increase or decrease by generation or load in a timeframe of two seconds or less, to correct a supply-demand imbalance and assist in managing power system frequency"

The NER allow for FFR to be procured under certain situations including:

- **As fast raise and lower FCAS**

  While this is not the current practise, AEMO has discretion to determine in the market ancillary service specification (MASS), the performance criteria for each of the existing market ancillary services and AEMO could re-purpose the existing fast raise and lower services to provide FFR. For reference, the NER definition of the fast raise(lower) service is:

  The service of providing, in accordance with the requirements of the *market ancillary service specification*, the capability of rapidly controlling the level of *generation* or *load* associated with a particular *facility* in response to the locally sensed *frequency* of the *power system* in order to arrest a fall(rise) in that *frequency*.

- **By the TNSP as inertia support services**

  Inertia support services, which may include FFR, may be procured by a TNSP which is the Inertia Service Provider for an inertia sub-network (typically a NEM region). Inertia support services can act to adjust the minimum and secure operating levels of inertia for islanded operation of an inertia sub-network. This arrangement allows for contracting of capacity in advance to support the secure operation of an islanded sub-network.

  AEMO has declared an inertia shortfall for the secure operating level of inertia to operate SA as an islanded system for the period 2020/21 and 2021/22. AEMO is currently working with ElecrtaNet to secure provision of FFR as inertia support services to resolve this shortfall.

A.3 Primary frequency response - policy options

Policy options for PFR

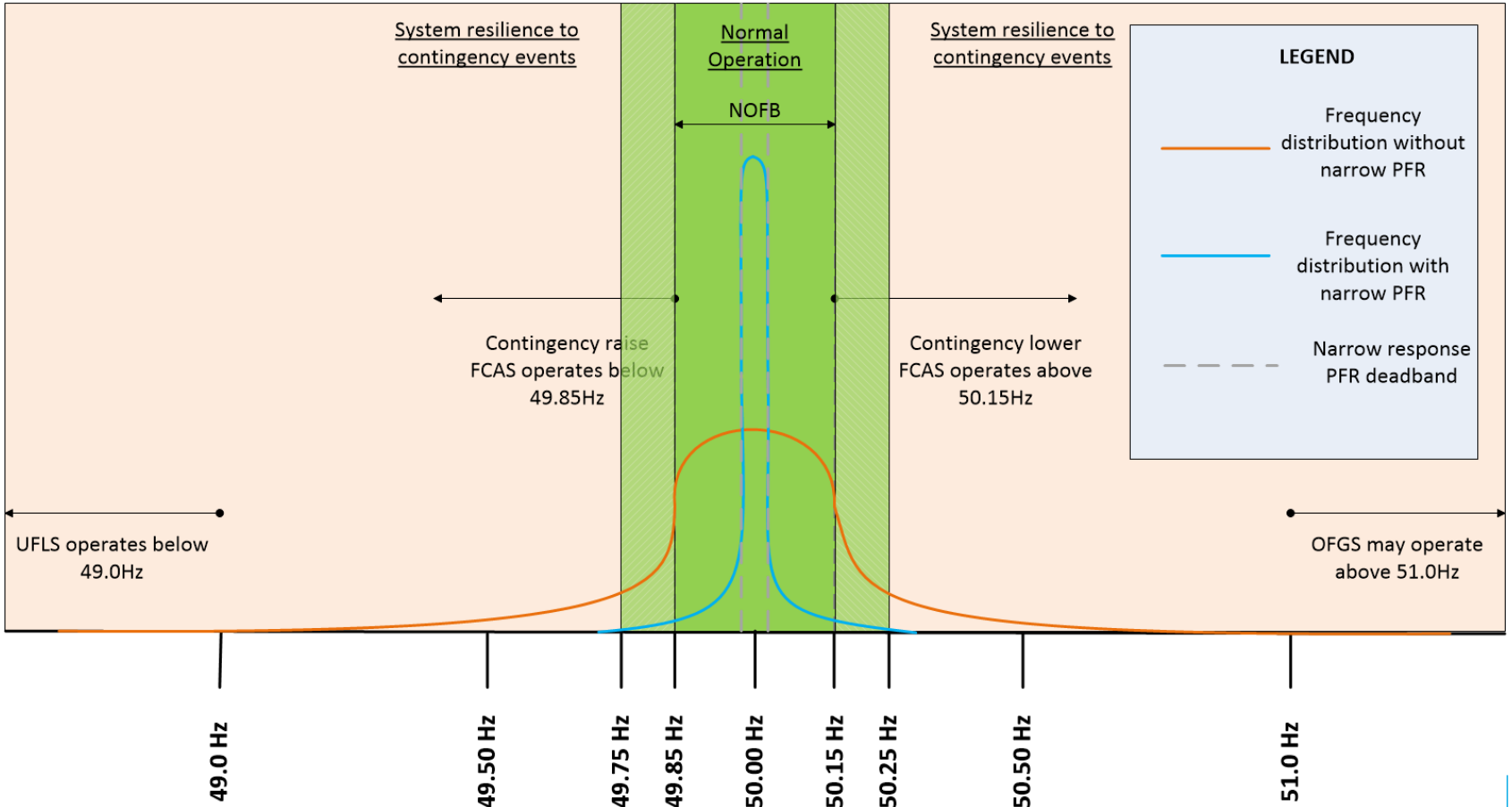
The following PFR policy options were previously considered by the AEMC through the 2018 *Frequency control frameworks review*:

~~A. Narrow band PFR provided by regulating FCAS~~	AEMO has previously advised that option A & B will not meet operational requirements for broad based continuous PFR
~~B. Narrow band PFR provided by contingency FCAS~~	
C. Mandatory PFR - (in place until 4/6/23)	Included in reform pathway 1 & 2.
~~D. Structured – contract procurement~~	Does not align with the ESB post 2025 market design vision.
E. New market ancillary service – Primary regulating service	Complementary to reform pathway 2 & 3.
F. Performance based PFR incentives – using regulation FCAS contribution factors (double-sided causer pays)	Complementary to reform pathways 1, 2 or 3.
G. Performance based PFR incentives – measured separately to regulation FCAS factors	

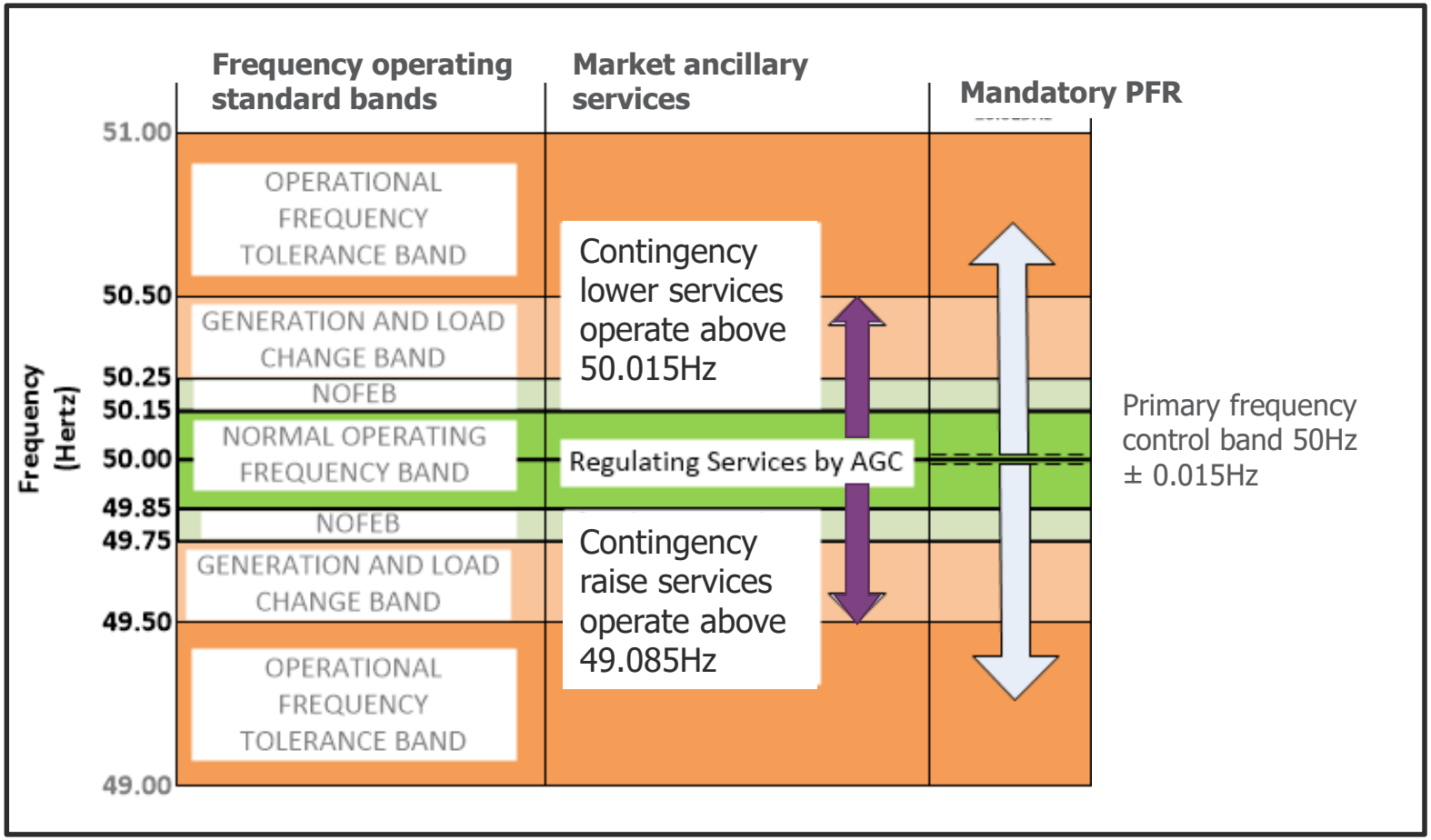
In addition, the following option was identified by stakeholders through the consultation on the Mandatory PFR rule:

H. Regulated PFR payment to complement a mandatory requirement	Complementary to reform pathways 1, 2 or 3.

A.4 Primary frequency response bands and frequency distributions



A.5 – Existing Frequency control frameworks - overview



A.6.1 WEM frequency control reforms - Overview

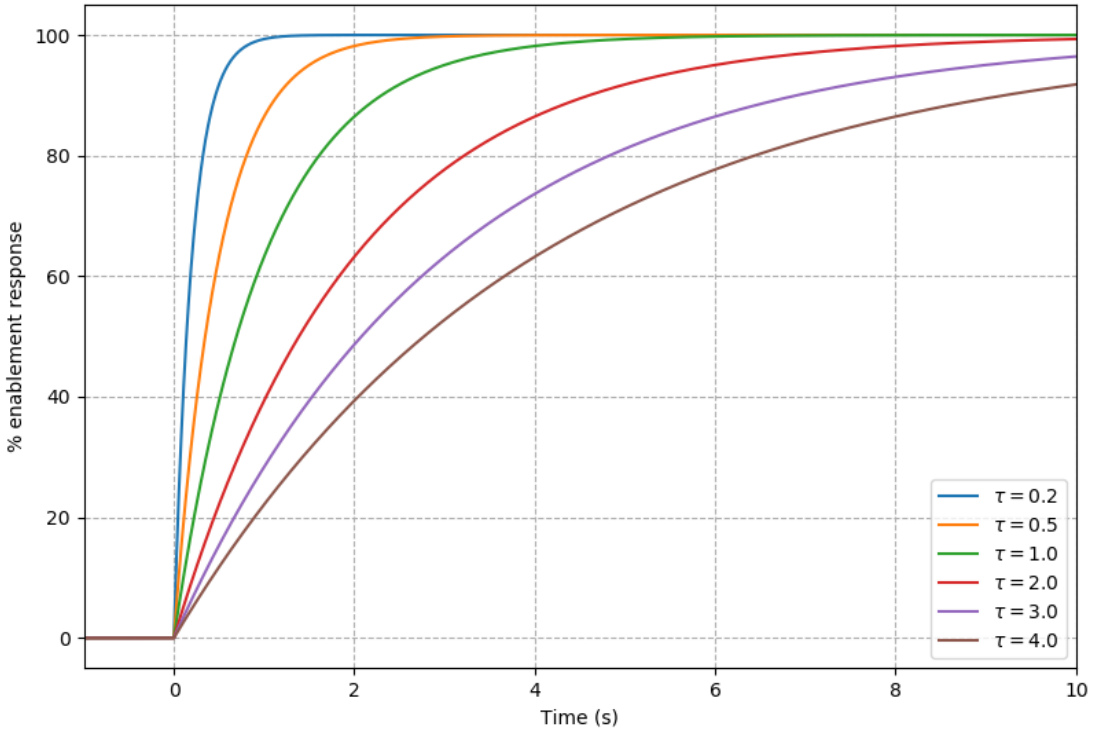
- In WA, AEMO is helping to develop revised frequency control arrangements as part of WA Government's Energy transformation taskforce.
- In the context of the small size of the WA power system, the taskforce determined that single-segment Contingency response markets were most appropriate for the WEM. This reform process intends to reform the existing WEM frequency control ancillary services as per the table below.

Current WEM Ancillary Services	NEM FCAS	Future WEM Essential System Services
Load Following (Up / Down)	Regulation (Raise / Lower)	Regulation (Raise / Lower)
Spinning Reserve (6s, 60s)	R6, R60, R5	Contingency (Raise / Lower)
Load Rejection (6s, 60s)	L6, L60, L5	
		ROCOF Control (inertia)

A.6.2 WEM frequency control reforms – contingency services

- Providers of the contingency service will be required to sustain their active power response for at least 15 minutes (CONSOLIDATED DRAFT AMENDING RULES FOR WEM "TRANCHE 1" cl. 3.10.3)
- Temporal spread of frequency response will be provided through the dispatch engine with the use of facility speed factors and power system performance factors.
- The 'speed factor' will be pre determined for each facility as part of the registration to be a service provider.

Figure: Proposed speed factors for WEM contingency service



Source: AEMO

A.6.2 WEM frequency control reforms – contingency services

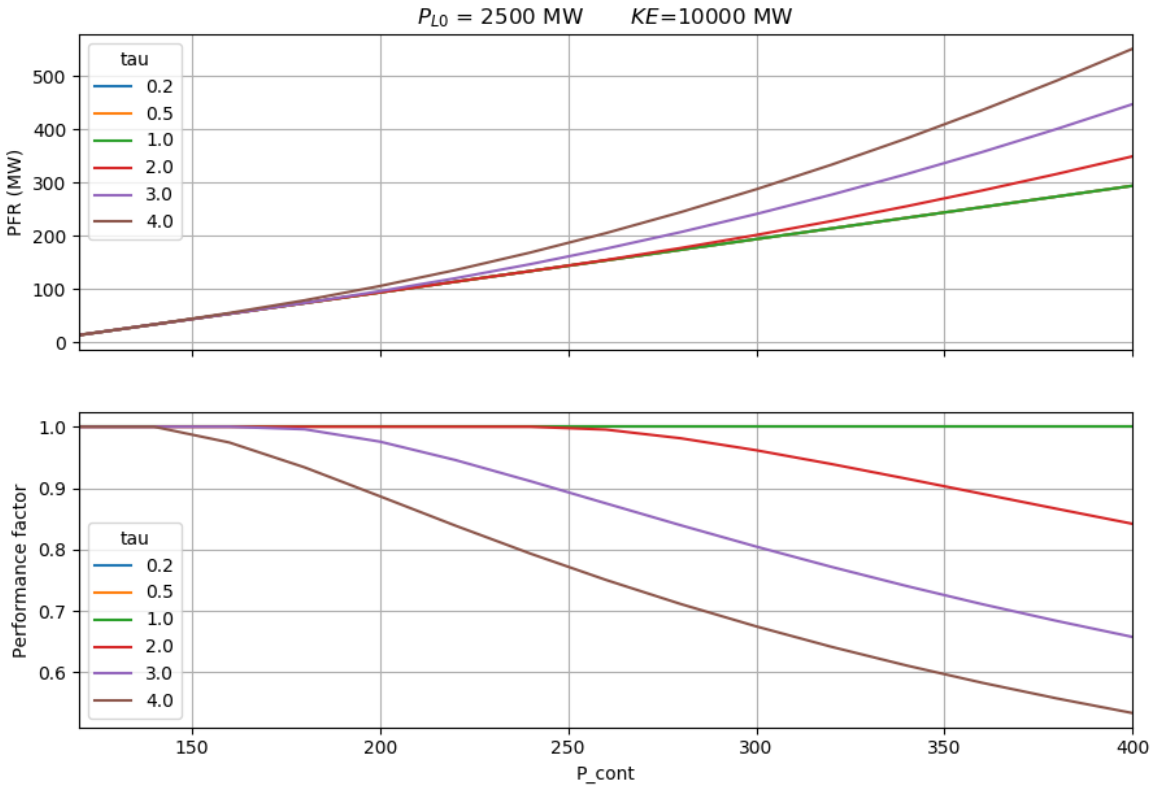
- The 'performance factor' is a pre-calculated function based on system load, inertia, contingency size and facility speed factor
- The performance factor will be used in dispatch to deliver a spread of contingency responsive reserves subject to the system operating conditions.

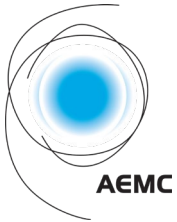
Ref.

Transformation Design and Operation Working Group Meeting 11 – 29 April 2020

Transformation Design and Operation Working Group Meeting 4 – 19 November 2019

Figure: Proposed performance factors for WEM contingency service





Office address
Level 15/60 Castlereagh St,
Sydney NSW 2000

Postal address
GPO Box 2603
Sydney 2001

T (02) 8296 7800
F (02 8296 7899