Frequency Performance Payments (FPP) Frequently Asked Questions (FAQ)

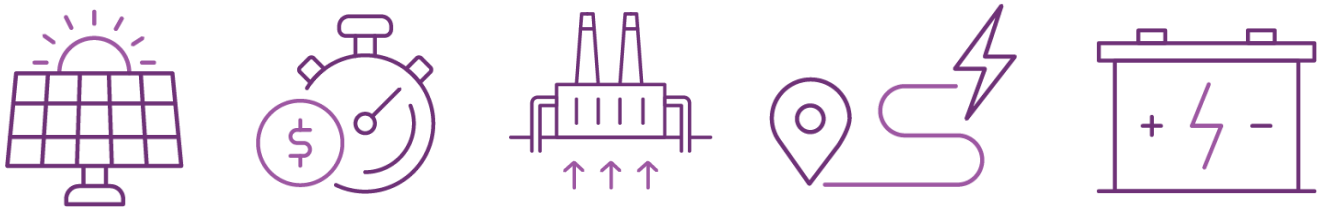
Executive Summary

This FAQ has been developed as a stakeholder resource for use during the implementation of the FPP Reform. There are answers are provided to important questions, as listed in the contents, about the basis for the reform, how the new arrangements will work, the period of non-financial operation, project timeline and other ways to engage with the implementation process.

This FAQ will be maintained as a living document and updated as stakeholders ask new questions and the reform process progresses.

This FAQ is part of a suite of resources that AEMO has developed to assist stakeholders to navigate the FPP implementation process. All resources are available on, or from, the FPP project page on AEMO's website.

Any questions about the FPP reform can be directed to NEMReform@aemo.com.au.



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Version History

Version	Date	Summary of changes
6	15 April 2025	Updated to include the following questions: • Why do some FPP units have a negative contribution factor value that is different from the NCF value? • Where can FPP Public Data be accessed?
5	21 January 2025	Updated to include the following questions: • Where can I find reason flags for RCR and Usage? • Why is the Usage or RCR value 'zero'?
4	17 December 2024	Additional detail added in answer to the question "Will all new FPP tables in the participant data model be populated from the start of NFO"? on page 25.
3	9 December 2024	Updated to include the following questions: • What will happen when the frequency measure and actual system frequency are misaligned? • Regarding Usage formulas, how is the 4-second interval nominator aggregated to match the 5-minute interval denominator? • Will there be a review of the non-financial data during Non-Financial Operation to see how the market is trending? • How accurate is the data being populated in the pre-production environment? • When batteries can ramp up instantly, should they still follow the gradual ramp-up outlined in the reference trajectory to avoid giving unhelpful performance? • Will all new FPP tables in the participant data model be populated from the start of NFO? • Is unit performance determined at a NEM-wide level? • What happens when a region of the NEM is islanded? • How are delays in the receipt of instructions to units, other data issues or brief spikes in system frequency taken into account? Could these contribute lead to negative financial outcomes for participants? • Is the reference trajectory always a straight line for all types of generators? • How will Regulation FCAS be recovered under the new FPP system? • When a raise or lower requirement affects multiple states, how does AEMO calculate the absolute sum of performances for that requirement? • Will the data published on NEMWeb during the NFO continue to be published on NEMWeb after the FPP Financial Go Live? • Has there been any documents released on the differences between 5.4 & 5.5 data models (DM)? Besides the go-live for settlements what are the main differences? • How frequently will the 4-second data be published? • What is substituted performance? • Why does a unit have the same contribution factor against two constraints? • How to determine the total amount of generation in a region used to calculate the FM for RCR? • What happens when there are multiple dispatch runs? • Why has Frequency Measure been deemed unreliable?
2	September 2024	Updated to include the following questions: • Has modelling been undertaken of how the new FPP arrangements will improve system frequency? • Will participants have the potential to forward their local frequency readings to better align measurement and performance? • Will a unit which is enabled to provide Regulatory FCAS receive both a positive FPP CF and their Regulation FCAS compensation?

Version	Date	Summary of changes
		• Has the FPP calculation been tested on historical market data and what did that analysis say about the impacts on different types of generators? • How will AEMO replace any bad quality SCADA data that is received? • Will auxiliary loads, which are attached to some generators, be separately assessed for FPP or aggregated? • Will FPP be separated from Regulation FCAS in settlement statements? • How will NFO data be provided to participants? • How will AEMO estimate Default Contribution Factors (DCFs) when a new constraint binds in Pre-Dispatch (PD)?
1	February 2024	First issue

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Frequently Asked Questions (FAQs)

FAQs are presented across five topics:

1. **Overview of the FPP reform**, including its origins, intended purpose and expected impacts.
2. **Measurements and calculations** used in the new system, including in determining the different contribution factors (CFs) used to allocate incentive payments and penalties.
3. **Non-financial operation (NFO)**, including its purpose and timing.
4. **Implementation of the FPP reform**, including how stakeholders can participate in the process at varying levels.
5. **Further information** that is available to participants and other stakeholders, including detailed specific documents and other resources**.**

AEMO intends to add more questions and answers to this document, as additional elements requiring explanation are revealed through stakeholder inquiries.

1. Overview of the FPP reform

Who made the decision to introduce the FPP reform?

The Australian Energy Market Commission (AEMC) recognised the need for a new framework of incentives for NEM participants to improve their provision of primary frequency response (PFR). The AEMC made a final determination in the Primary Frequency Response Incentives rule change on 8 September 2022.

The AEMC mandated a suite of measures, intended to:

- "give AEMO the tools it needs to manage the secure operation of the power system" in accordance with the FOS
- "deliver more efficient operation of power system plant and encourage innovation and investment in new capability to help control power system frequency, thereby lowering costs for consumers over the long term", through a system of incentives and penalties based on individual unit performance.

The AEMC characterised the changes as fitting into three categories:

1. **The extension of mandatory PFR requirements** for all scheduled and semi-scheduled generators and scheduled loads (removing an existing June 2023 sunset to such arrangements and is now an enduring obligation).
2. **Introducing the new FPP process**, which creates a new double-sided system of incentive payments and penalties based on units' impact on system frequency.
3. **New reporting obligations** on AEMO and the Australian Energy Regulator, related to reporting on the aggregate level of frequency response and the total cost of the scheme.[1]

Why is the FPP reform needed?

Frequency can be thought of as the 'speed' at which a power system operates. System frequency varies whenever the electricity supply does not exactly match consumer demand. Stable frequency is a fundamental requirement to maintain the secure operation of the power system. The changing National Electricity Market (NEM) generation mix and increasing

[1] AEMC, Primary Frequency Response Incentive arrangements - Final Determination, 8 September 2022, p1.

number of inverter-based resources such as large-scale wind and solar farms, as well as the high uptake of rooftop PVs, make maintaining the supply-demand balance more challenging. Consequently, keeping the frequency within a limited range around its nominal value has become more difficult. This means new measures are required to support the operation of the power system in accordance with the standards stipulated in the Frequency Operating Standard (FOS).

The new arrangements encourage all facilities to operate in a way that helps maintain power system frequency within the normal operating band, at the lowest cost to consumers.

What are the elements of the new FPP system?

As outlined in the FAQ "Who made the decision to introduce the FPP reform?", the AEMC characterised the new FPP system as one of three elements of the PRF incentives rule change. The new FPP process, one of those elements, is itself divided into two parts, being to:

- Introduce a new system of incentives and penalties that will see scheduled generators and semi-scheduled generators, scheduled loads and semi-scheduled loads either receive or be liable for payments, based on whether they have had a helpful or unhelpful impact on system frequency. These are the frequency performance payments that give their name to the overall reform.
- Use the CFs determined for FPPs, which are calculated for every five-minute interval, to allocate the cost of Regulation Frequency Control Ancillary Services (FCAS). The cost of Regulation FCAS is currently allocated via the Causer Pays framework.

Where does the new bucket of money come from and how is it allocated?

The new FPP process is a financial mechanism used to incentivise plant behaviour that helps control power system frequency. Participants that have a helpful impact on system frequency will receive payments, while those that have an unhelpful impact will pay penalties. The total amount of penalties equals that of incentives in each five-minute interval. The total amount of FPPs is determined based on the price of Regulation FCAS and the size of helpful response by units. Effectively, those facilities that have a helpful impact on power system frequency receive payments, which are funded by the penalties paid by facilities that had an unhelpful impact on power system frequency.

What changes are being made to Causer Pays?

The cost of Regulation FCAS is currently allocated to market participants using the methodology known as Causer Pays. Under Causer Pays, if a unit has more unhelpful frequency performance than helpful, then it is charged a share of Regulation FCAS costs. If a unit has more helpful frequency performance, it can avoid paying for Regulation FCAS. The share of each market participant (contribution factor) is multiplied by the cost of Regulation FCAS to calculate a debit amount in settlement. The performance of units for a market participant is assessed over a 28-day period and the determined contribution factor is applied for 28-days. The same factor applies to both Raise and Lower Regulation FCAS.

The FPP reform will completely replace the current Causer Pays methodology with new arrangements, under which:

- The Regulation FCAS costs used in a trading interval will be allocated based on negative contribution factors (NCFs) determined for the trading interval.
- The Regulation FCAS costs not used in a trading interval will be allocated based on default contribution factors (DCFs), which are intended to reflect the longer-term historical performance of a facility.

Who will be the winners and losers of the new scheme?

The new arrangements are designed to promote the provision of good frequency control in the NEM at the lowest cost to consumers. This is achieved by more clearly pricing the impact of helpful and unhelpful behaviour by facilities and providing information about performance in a timeframe that allows for plant operators to respond to these price signals.

Facilities behaving in a way that is helpful for system frequency – including by closely following their expected output trajectory or by providing PFR – are expected to see positive FPP flows.

Facilities that experience variable output, especially generation that falls short of forecasts levels, are likely to be liable for FPP penalties, as well as have relatively higher liability for Regulation FCAS costs.

Has modelling been undertaken of how the new FPP arrangements will improve system frequency?

The policy objective of the FPP reform is to incentivise better primary frequency control. The design of the mechanism is to provide participants with a clear price signal (positive or negative economic incentive) about the cost and value of beneficial frequency performance. As more units adopt control measures to improve frequency control, the anticipation is that frequency control will improve.

The results of any modelling of the effects the new FPP arrangements would be highly dependent on the assumptions made about how much participants respond to the price signals. Because the FPP incentive mechanism is new, there is no revealed data about how participants will respond on which such assumptions could reasonably be based. Accordingly, no modelling of the effect of FPP on frequency over time has been modelled.

How can a participant improve their FPP outcomes?

Under the FPP reform, market participants will be rewarded for helpful performance and penalised for unhelpful performance. The amount debited is strongly linked to how closely a unit's output follows its expected trajectory. Facilities that deviate from their Reference Trajectories in an unhelpful manner can expect to receive FPP penalties.

Market participants can improve the alignment of a unit's behaviour with its Reference Trajectory through the options listed below.

- Capital investments in technologies that are able to follow plant's set points more closely and/or provide primary frequency response would improve the FPP outcomes of variable renewable energy (VRE) facilities such as solar and wind farms. For example, the helpful performance of a co-located battery can compensate for the variation from solar/wind farms, especially when their generation falls short of forecasted output (i.e. "firming" the renewable output).
- Increasing their headroom to compensate for the inherent limitations on forecasting VRE output. If facilities have a larger buffer for when they cannot meet their targets, they can reduce the degree to which they deviate from their reference target at that time.
- Improving the accuracy of their self-forecasts. The expected output provided to AEMO by participants who self-forecast directly impacts their Reference Trajectory, other than when there are limitations in the network. The more accurate these forecasts are to their actual output, the smaller their deviations.

2. Measurements and calculations

How are FPPs calculated?

The process runs every 5 minutes to determine the FPP trading amounts and the allocated Regulation FCAS costs for each unit in the past trading interval.

- AEMO evaluates the performance of a unit based on whether it behaved in a way that helped to correct power system frequency towards 50 Hz.
- The unit's performance is used to calculate a CF. This CF is between -1 and 1, with negative values indicating an unhelpful response and positive values a helpful one.
- AEMO also uses the historical performance of the unit to determine a Default Contribution Factor (DCF).
- To assign a monetary value to the unit's performance for FPP, AEMO multiplies the CF by a scaling factor, which is the system's valuation of frequency response within the trading interval.
- Finally, AEMO uses both the CF and the DCF to determine the allocated Regulation FCAS costs for the unit.

The figure below illustrates the calculation overview workflow.

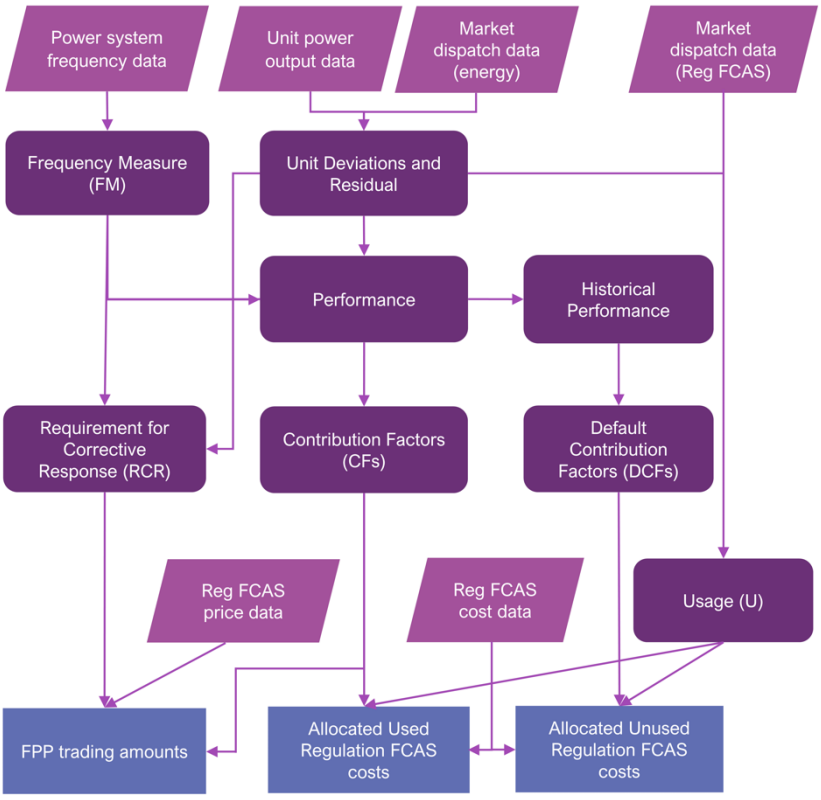

Figure 1 Flow chart of the FPP process

How is Performance calculated?

Performance refers to the degree to which a unit contributes to the need to raise or lower the frequency of the power system. For each unit, AEMO calculates two performance values every 4 seconds – one for when there is a need to increase the system frequency and the other for when there is a need to lower the system frequency. The aggregates of these 4-second performances respectively form the unit's Raise and Lower Performance over the 5-minute trading interval. A unit's 4-second performance is calculated based on the Frequency Measure (FM) and the deviation of the unit from its Reference Trajectory.

Further details on the formulation of Raise Performance and Lower Performance can be found in Sections 6.2.1. and 6.2.3. of the Frequency Contribution Factors Procedure (FCFP) respectively.

What is the Frequency Measure (FM)?

Frequency Measure (FM) reflects the need to raise or lower power system frequency towards 50 Hz:

- A positive FM means the frequency should be increased.
- A negative FM means the frequency should be decreased.
- The larger the FM, the bigger the need.

How is the Frequency Measure calculated?

For every region, an FM value is calculated at each 4-second interval, using the frequency deviations (difference between instantaneous frequency and 50Hz) within that region. Instantaneous measurements are taken and used to calculate a smoothed value (the FM). Specifically, an exponential moving average is calculated with a smoothing factor of 2/9, corresponding to a filter of 28 seconds. The FM smoothing factor is one of the FPP Tuning Parameters and Input Sources published under, but not within, the FCFP.

The figure below shows the frequency deviations and FM of a region over six trading intervals.

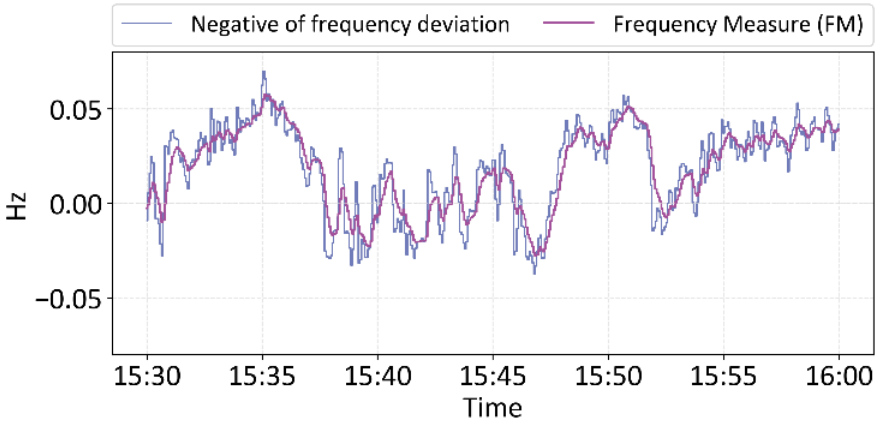

Figure 2 Example regional frequency deviation and frequency measure

Further details on the formulation of FM can be found in Section 4.1 of the FCFP. Discussion of AEMO's reasoning for certain design decisions can be found in Section 4.1 of the Draft Report of the FCFP Consultation (Feb 2023).

Why has Frequency Measure been deemed unreliable?

As defined in Section 4.3 of the FCFP, Frequency Measure data needs at least seven 4-second data points for both Raise Frequency Measure and Lower Frequency Measure within a trading interval (a trading interval has a total of 75 data points), to be flagged as reliable for performance calculation.

An example of when FM data is deemed unreliable is when a trading interval has 70 4-second intervals where the FM > 0. The remaining five 4-second intervals will be FM < 0. This will result in the FM Lower being classified as unreliable and the FM raise is classified as reliable, due to the volume of FM Lower data points being under the required threshold.

Will participants have the potential to forward their local frequency readings to better align measurement and performance?

No. The new system will use a single frequency value for each NEM region. When the power system is running on a steady state, frequency readings at the local and regional level would not be materially different.

What is a Reference Trajectory?

A unit's Reference Trajectory shows its expected active power output or consumption. Simply put, it is a straight line between two dispatch targets five minutes apart.

What is an example of a unit's Reference Trajectory?

The Reference Trajectory of Scheduled and Semi Scheduled units is a straight line between the previous and current dispatch targets.

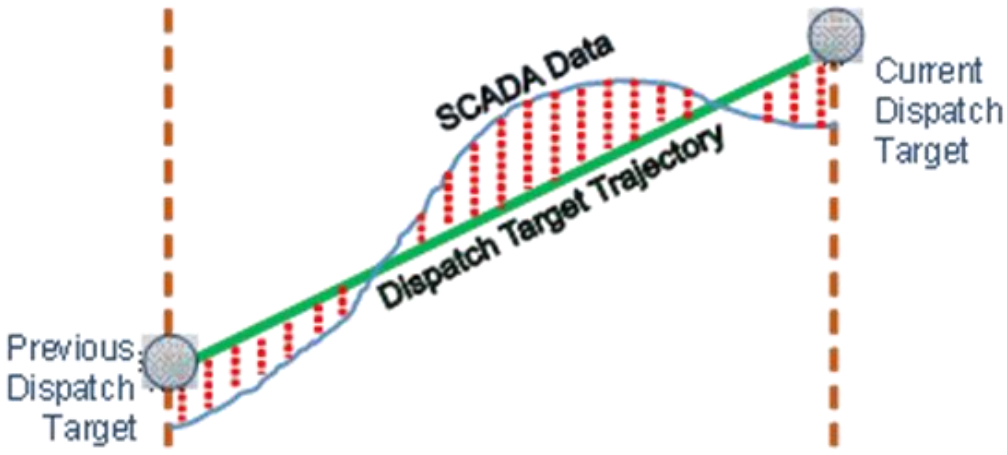

Figure 3 Reference trajectory of a scheduled unit

The Reference Trajectory of Non-Scheduled units is a continuation of the unit generation at the start of the current trading interval.

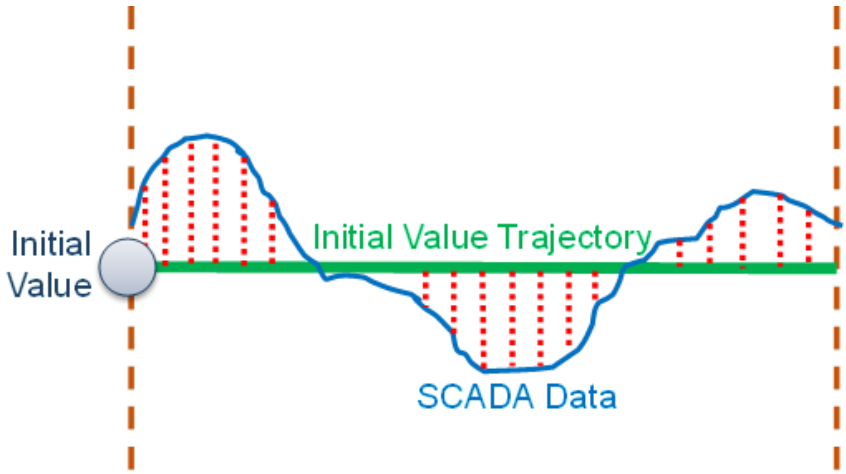

Figure 4 Reference trajectory of a non-scheduled unit

What is unit deviation?

AEMO calculates 4-second unit deviations (in MW) by comparing SCADA measurements against its Reference Trajectory. The sign of deviations is always with respect to the relevant region – a positive deviation is one that increases the net amount of energy within that region (more generation or less load), and a negative deviation has the opposite effect. The figure below shows the Reference Trajectory, 4-second SCADA measurements, and deviations of a unit over six trading intervals.

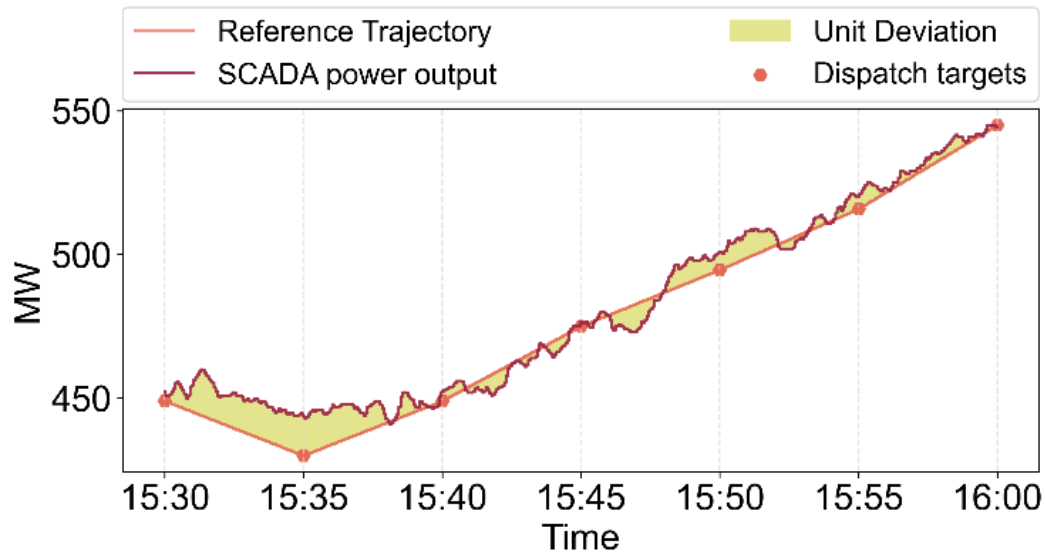

Figure 5 Example unit reference trajectory and deviation

Further details on the formulation of unit deviation can be found in Section 5 of the FCFP.

Is a positive deviation always a good thing?

No, a deviation that shares the same sign as the FM is deemed helpful and results in good performance and vice versa for a deviation that opposes the FM. The figure below illustrates this for a generating unit with PFR capability over six trading intervals.

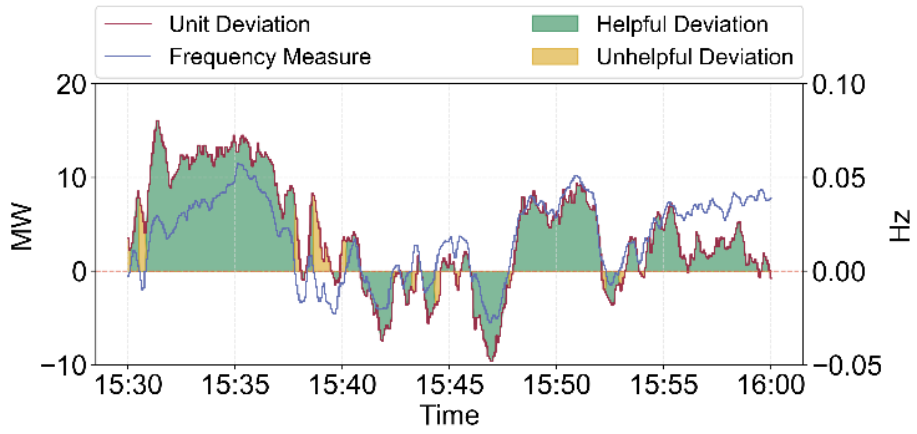

Figure 6 Helpful/unhelpful unit deviation visual

What is a contribution factor?

A contribution factor reflects the extent to which the unit contributed to the helpful or unhelpful control of system frequency control in relation to each binding FCAS requirement.

What is the difference between a negative and a positive contribution (CF) factor?

A CF is between -1 and 1, where:

Negative values show a unit's unhelpful frequency performance and are used to determine penalties in the FPP system.

Positive values reflect a unit's helpful performance in frequency control and are used to determine incentives in the FPP system.

How is a contribution factor calculated?

In every trading interval, AEMO calculates a CF for a unit in relation to each Regulation FCAS Requirement that is related to the unit.

For each unit, within each trading interval and respective to a requirement, the CF of a unit is determined based on the Performance values as follows:

$$CF = \frac{\text{Unit's Performance}}{\text{Total Performance of all units in the requirement that have the same sign}}$$

Further details on the formulation of a unit's Raise CF and Lower CF can be found in Sections 6.2.2. and 6.2.4. of the FCFP respectively.

What is the historical performance period (HPP)?

A seven-day period, starting at 12:00 AM on a Sunday and ending at 12:00 AM on the following Sunday, which concludes 14 days prior to the commencement of the billing period, inclusive of the 5 business days' notice period, as referred to in NER 3.15.6AA(i). The figure below illustrates the timing for of the HPP.

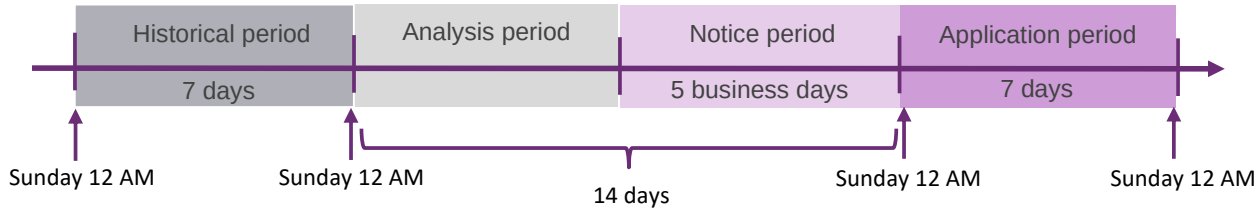

Figure 7 HPP and DCF calculation timeline

What is Historical performance?

Historical Performance quantifies how helpful/unhelpful the unit's frequency performance was over the 7-day historical period (HPP).

How is Historical performance calculated?

AEMO calculates Raise and Lower Historical Performances for each unit, every week, based on the unit's Performance values over a 7-day historical period.

Historical Performances are calculated differently for Regulation FCAS cost and FPP:

- For Used and Unused Regulation FCAS recovery: Performances at each 5-min interval in the historical period are capped at zero, then averaged.
- For FPP: Performances are averaged over the historical period, then capped at zero.

Further details on the formulation of default historical performance can be found in Section 6.4 of the FCFP.

What is a default contribution factor?

A Default Contribution Factor is a contribution factor that is determined based on the historical performance of units. Further details on the formulation of default contribution factors can be found in Section 6.4. of the FCFP.

How is a default contribution factor used?

Default Contribution Factor are used in two different ways:

1. For Unused Regulation FCAS cost allocation, DCFs are always used.
2. For Used Regulation FCAS cost allocation and FPP, DCFs are used only when the performance of a unit cannot be calculated in a trading interval.

What is substituted performance?

If a unit's performance cannot be calculated due to bad quality or unavailable data, substituted performance values will be used to ensure a Contribution Factor can be calculated for a unit.

The FPP application will substitute null performance values with

- FPP historical performance values when calculating contribution factors and residual contribution factors
- Regulation historical performance values when calculating negative contribution factors.

What is the Requirement for Corrective Response (RCR)?

The RCR represents the peak volume of helpful response provided by all units in a given trading interval. An RCR is determined with respect to each Regulation FCAS Requirement and is used to scale the monetary value of FPP trading amounts. The larger the RCR value then the larger the value of FPP trading amounts.

The figure below depicts how the RCR corresponds to the maximum of the sum of all helpful deviations (including both units and Residual) during that interval. Noting that the positive and negative deviations are symmetrical as it is assumed that residual deviations (deviations of units without appropriate metering) is the opposite of the sum of all other deviations.

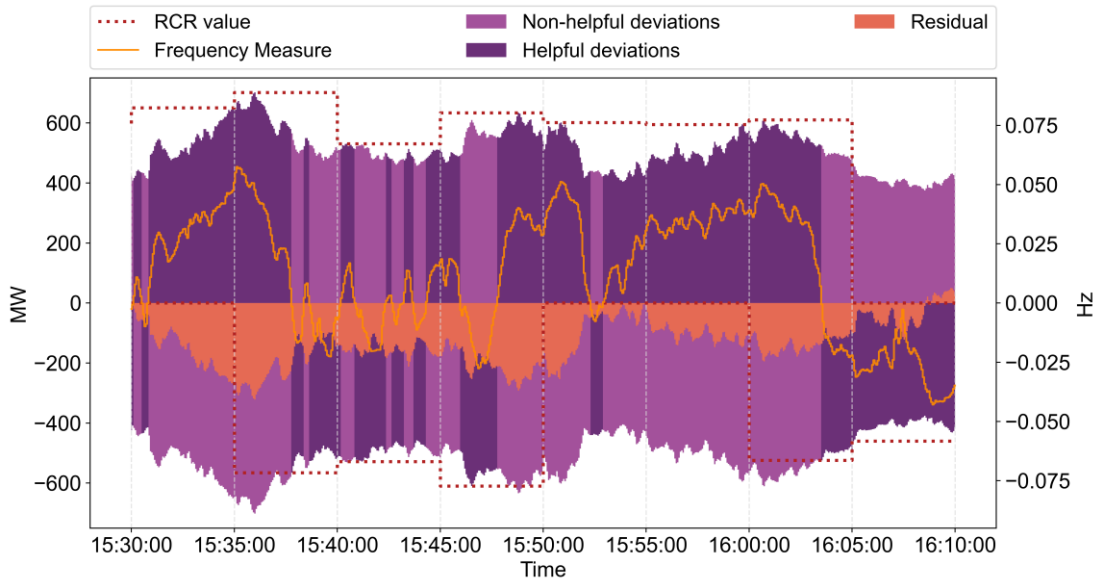

Figure 8 Visualization of Requirement for Corrective Response (RCR)

Further details on the formulation of Raise RCR and Lower RCR can be found in Sections 7.3. and 7.4. of the FCFP respectively.

How to determine the total amount of generation in a region used to calculate the FM for RCR?

The total amount of generation (Section 7.1 of the FCFP) is determined from the Operational_Demand calculation plus a weight constant. For each trading interval, the Operational_Demand is defined as:

$$Operational\_Demand = TotalDemand + ClearedSupply - DispatchableGeneration + NetInterchange$$

The weight constant is defined in the Tuning Parameters and Input Sources document. This weight constant is introduced to manage scenarios when demand is low, and participants will be informed of the value via updates to the Tuning Parameters document.

The same concept is applied for estimated ATE, which is used to calculate the estimated residual cost rate (Section 10.1 of the FCFP):

$$Estimated\ ATE = Operational\_Demand + Weight\ Constant$$

What determines the total amount of FPPs in a trading interval?

The total amount of FPPs is calculated in each trading interval and with respect to each Regulation FCAS Requirement. AEMO determines a price for FPPs based on the marginal cost of each Regulation FCAS Requirement as determined by the market management systems. This price is then multiplied by the RCR to calculate the total amount of FPPs based on the amount of frequency response provided by eligible units.

How is a unit's FPP trading amount calculated?

The FPP trading amount for units with appropriate real-time telemetry will be determined as:

$$TA = CF \times \frac{P_{regulation}}{12} \times RCR$$

Where:

CF - Contribution Factor.

$P_{regulation}$ - marginal cost of the Regulation FCAS Requirement.

RCR - Requirement for Corrective Response

What is Usage?

Usage reflects the proportion of enabled Regulation FCAS that was used within a trading interval. Usage determines the percentage of Regulation FCAS costs to be recovered on the basis of NCFs and the percentage to be recovered on the basis of DCFs.

How is usage calculated?

In each trading interval, Usage is calculated for each Regulation FCAS Requirement. Raise Usage is the maximum of the sum of units' positive deviations that are enabled for a raise Regulation requirement. Lower Usage is the maximum of the absolute sum of units' negative deviations that are enabled for a lower Regulation requirement.

Further details on the formulation of Usage can be found in Section 8. of the FCFP.

How will Regulation FCAS costs be allocated under FPP?

Under FPP reforms, the cost of Regulation FCAS will be recovered from units that have unhelpful frequency performance. The trading amounts will be allocated based on the amount of enabled Regulation FCAS that was used and unused within a trading interval, as follows:

$$TA_{used} = TSFCAS \times U \times NCF$$
$$TA_{unused} = TSFCAS \times (1 - U) \times DCF$$

Where:

$TSFCAS$ – the total cost of the Regulation FCAS requirement.

U – Usage. Usage reflects the proportion of enabled Regulation FCAS that was used within a trading interval.

NCF – Negative Contribution Factor.

DCF – Default Contribution Factor.

Will the reform increase the cost of Regulation FCAS?

AEMO does not expect the reform to increase the price of Regulation FCAS itself.

The new FPPs will create a new bucket of money into which facilities with unhelpful frequency performance will pay. The amount of FPP costs in any five-minute interval will depend on the price of Regulation FCAS and the size of deviations of all units in the system from their expected generation / consumption (the bigger the deviations, the higher the FPP amounts).

As FPPs could be paid to any unit that has helpful frequency performance in a five-minute interval, each unit that pays for FPPs in some five-minute intervals will potentially receive FPPs in some other intervals, depending on its performance. This means, over time, a material amount of positive and negative FPPs for a unit will offset each other. This was explained to stakeholders at the FPP consultation briefing on 15 February 2023 through a historical analysis conducted by AEMO. The analysis showed while the total amount of FPPs could be the same size as Regulation FCAS costs, the net amount of FPP costs would be about 30% of the Regulation FCAS costs.

The actual size of the FPP costs will, however, depend on how generators change their behaviour in response to the signals that the new arrangements will produce. Because of this behavioural change element, as well as the ongoing changes in the generation mix, AEMO is not able to confidently model a final cost impact.

It is important to note that this cost increase is an intended outcome of the reform. Under the new arrangements, this cost would be paid to the units with helpful frequency performance. Over time, these financial incentives for helpful frequency performance should help the control of power system frequency at lowest overall cost to consumers.

Will a unit which is enabled to provide Regulatory FCAS receive both a positive FPP CF and their Regulation FCAS compensation?

Units enabled for Reg FCAS will simultaneously be captured by the FPP calculation. Units providing Reg FCAS are not guaranteed to receive an FPP incentive payment, rather than incurring a liability – the FPP outcome in each trading interval is still dependent the unit's performance, including when it is providing Reg FCAS.

Based on AEMO's analysis of what FPP outcomes would have been if the new rules were applied to a specific period of actual performance by facilities in the NEM, facilities providing Reg FCAS will generally, but not always, be deviating from their reference trajectory in a way that is beneficial for system frequency and, therefore, receive FPP incentive payments.

What is the Residual?

The Residual refers to all facilities connected to the grid without appropriate real-time telemetry (4-second SCADA measurements) including small consumers and distributed resources.

How is the Residual Deviations and performance calculated?

Residual Deviation and Performance is calculated on a regional basis. Since the Residual does not have 4-second data, AEMO aggregates the Deviations of all units with appropriate metering and the interconnectors within the region, then takes the opposite of that sum to determine the Deviation of the Residual. Similar to the units, the Residual Deviation is used to calculate its Performance.

Further details on the formulation of Residual Deviation can be found in Section 5.3. of the FCFP.

How are the trading amounts of units without appropriate metering calculated?

To find the FPP trading amounts of loads and generators that do not have appropriate metering (i.e., are part of Residual), AEMO distributes the trading amount of the Residual among them with respect to their total adjusted gross energy amounts (in MWh). On this basis, the trading amount of the unit will be determined as:

$$TA = RCF \times \frac{P_{regulation}}{12} \times RCR \times \frac{TE}{ATE}$$

Where:

RCF – Residual Contribution Factor (Refer to section 6.2 of the FCFP for the calculation).

$P_{regulation}$ - marginal cost of the Regulation FCAS Requirement.

RCR - requirement for corrective response.

TE – unit's energy (MW)

ATE - total energy (MW)

How are regulation costs allocated to the units without appropriate metering?

To allocate the Regulation FCAS cost among loads and generators that do not have appropriate metering (i.e., Residual), AEMO distributes the allocated cost of the Residual among them with respect to their total adjusted gross energy amounts (in MWh). On this basis, the cost allocated to each unit is determined as:

$$TA_{used} = TSFCAS \times U \times NRCF \times \frac{TE}{ATE}$$

$$TA_{unused} = TSFCAS \times (1 - U) \times DRCF \times \frac{TE}{ATE}$$

Where:

$TSFCAS$ – the total cost of the Regulation FCAS requirement.

U – Usage. Usage reflects the proportion of enabled Regulation FCAS that was used within a trading interval.

$NRCF$ – negative Residual contribution factor.

$DRCF$ – default Residual contribution factor.

TE – absolute value of unit's gross consumed or generated energy amount (MWh)

ATE – sum of absolute value of gross consumed or generated energy amount for all units without appropriate metering (MWh)

Do participants that are part of the Residual have their own contribution factors?

They do not receive a CF based on how helpful an impact they have had on system frequency in each five-minute trading interval. They do, however, receive DCFs, based on their energy consumption over a seven-day period (check/ref).

How can facilities that are part of the residual get an individual CF?

In some instances, facilities may be able to arrange for the provision of real-time telemetry in order to have an individual contribution factor calculated, which may be more favourable than receiving a proportion of the Residual.

Has the FPP calculation been tested on historical market data and what did that analysis say about the impacts on different types of generators?

The FPP reform has been tested on 80 days of data, which included both historical market data and 4-second data of generators. Outcomes of that assessment are shown in slides 8-25 of this presentation from a stakeholder workshop held on 15 April 2022. It is important to note that the outcomes are based on applying the FPP calculation to actual participant performance over the period between July and October 2021 and do not factor in the impact of any behavioural response from participants to FPPs economic incentives. The growth in grid-scale energy storage systems since that time will also impact the outcomes for all facilities.

How will AEMO replace any bad quality SCADA data that is received?

Under the new FPP arrangements, AEMO will calculate both Contribution Factors (CFs), for each five-minute trading interval, based on four-second SCADA data, and Default Contribution Factors (DCFs), based on unit performance over a seven-day period. These DCFs are used to allocate unused Regulation FCAS under all circumstances and substituted for CFs when sufficient quality SCADA data is not available. The number of four-second intervals that must be missing for SCADA to be considered bad for that trading interval, referred to as the significance threshold, is one of the FPP tuning parameters published under the FCFP. The significance threshold for bad SCADA is seven (7) non-consecutive four-second intervals within a trading interval with bad-quality of missing data.

What data will be reported to facility operators?

The economic theory behind the FPP reform relies on participants receiving very fast feedback (price signals) on their performance, potentially prompting a change in behaviour (that is more beneficial to power system frequency). At the completion of the FPP calculations for each five-minute trading interval, AEMO will provide all performance measurements and underlying calculations, as well as an estimate of financial outcomes (financial outcomes are not final until settlement and the end of each week). AEMO does not yet know how long each calculation will take.

The FPP Reporting Data Model technical specification (DM 5.3.1) will be published by 15 April 2024. In advance of the publication of that tech spec, AEMO has produced the FPP high level technical data design document, to assist participants in understanding the changes that will be introduced. The document includes:

- A succinct summary of FPP's background and intended purpose, as well as how calculations will be done and the remaining stages of the implementation process.
- Column names, business rules and other information about the 15 reports AEMO will provide to participants, including at the completion of each 5min calculation.
- Information about what current reports will be altered or discontinued from 8 June 2025.

The FPP high level technical design document has been provided to assist participants to understand how their own systems will be impacted and commence the process of scoping, and potentially procuring, necessary changes to their systems, ahead of the release of the FPP Reports tech spec (DM5.3.1) in April 2024 (at which point the information can be considered final).

Will auxiliary loads, which are attached to some generators, be separately assessed for FPP or aggregated?

Yes, provided that the facilities have been aggregated in accordance with NER 3.8.3, they will be assessed together for the purposes of FPP assessments.

Unit aggregation is addressed in Section 2.3 of the FCFP.

How will AEMO estimate Default Contribution Factors (DCFs) when a new constraint binds in Pre-Dispatch (PD)?

AEMO will provide participants with estimates of FPP outcomes as part of the 30-minute PD and P5min forecasting process. These estimates use DCFs, are calculated by averaging previous CFs. All FPP calculations, including CFs (and therefore DCFs) occur at the constraint level. This means that when new constraints are set to be invoked, there is no history of previous CFs from which to calculate a DCF for the purposes of PD and P5-min estimates. Accordingly, the FPP engine will use a zero value for DCFs when new constraint binds, meaning no individual estimates of FPP outcomes will be available (until after the first trading interval dispatched with the new constraints).

Is unit performance determined at a NEM-wide level?

All FPP calculations will occur at the binding constraint level, as is currently the case with Regulation FCAS. Accordingly, recovery would only be NEM-wide if a global constraint is binding.

What happens when a region of the NEM is islanded?

When islanding (AC separation) occurs (and is expected to continue for longer than a few minutes), AEMO's control room will adjust the constraint sets accordingly. However, depending on the cause of the islanding, this process could take 2-3 trading intervals (10-15 minutes). AEMO is including a feature in the FPP system that will seek to identify that an islanding has occurred (by detecting differences in frequency in each region) and send an alert to AEMO staff. Where the event has separated two regions that had been part of the same constraint, there will be no FPPs for that interval.

How are delays in the receipt of instructions to units, other data issues or brief spikes in system frequency taken into account? Could these contribute lead to negative financial outcomes for participants?

Because the FPP calculation process involves measurements of system frequency and unit performance taken every four seconds, it is inevitable that brief disturbances, data delays our 'outlier' readings will occur. To mitigate the impact of such volatility, the Frequency Measure used in the FPP calculations is determined using a 'smoothing factor'. Significant study was undertaken, as part of the development of the Frequency Contribution Factors Procedure, to determine a factor that would appropriately reflect the costs and benefits of facilities' performance.

Is the reference trajectory always a straight line for all types of generators?

Yes, it is a straight line between the previous and current dispatch targets for all scheduled and semi scheduled generators, or a straight line from the start of the current trading interval for non-scheduled unit.

How will Regulation FCAS be recovered under the new FPP system?

Regulation FCAS will still be recovered using negative contribution factors, with cost divided into used and unused component. The used portion will be charged based on contribution factors calculated trading interval, while the unused part will use historical default factors.

When a raise or lower requirement affects multiple states, how does AEMO calculate the absolute sum of performances for that requirement?

FPPs are calculated based on binding NEM constraints, not regions. A constraint could, for example, include multiple NEM regions or be global across the system.

How frequently will the 4-second data be published?

As soon as the calculation is complete for the trading interval.

What will happen when the frequency measure and actual system frequency are misaligned. Noting mandatory primary frequency response acts off power system frequency not the frequency measure?

There is an alignment test, which differs from the existing 'causer pays' alignment test.

A 4sec interval is ignored only if the frequency deviation is outside the Primary Frequency Response (PFR) deadband and has a non-correlated sign to the frequency measure. When frequency deviation is within the FPP deadband, an alignment test is not performed.

Regarding Usage formulas, how is the 4-second interval nominator aggregated to match the 5-minute interval denominator?

It is the maximum usage within the 5min period divided by the enabled regulation.

How accurate is the data being populated in the pre-production environment?

The reference trajectory calculations in pre-production is based on pre-production bids created during industry testing. In addition, the measured megawatt values reflect what is in the power system but may have a lag. As a result, the FPP calculations in pre-production do not reflect 'real' data or expected outcomes.

If an individual participant chose to bid in pre-production to reflect production outcomes, the deviation and performance will be close to reality. Note that Non-Financial Operation is not a managed trial.

When batteries can ramp up instantly, should they still follow the gradual ramp-up outlined in the reference trajectory to avoid giving unhelpful performance?

The simple answer is yes. In NEM we expect all units to move linearly to the target. If a battery does that, it will have 'neutral' FPP performance and will limit its exposure to cost recovery (or incentives)However, if a battery can provide deviations that are helpful to system, including through being responsive to frequency in real-time, it will be rewarded accordingly.

Why does a unit have the same Contribution Factor (CF) against two constraints?

Whilst unlikely, there may be occurrences where a unit has the same contribution factor value against two different constraints.

When constraints have the same region and bid type within a trading interval, then any unit linked to that constraint will have the same contribution factor, as the summed performance (denominator in the CF calculation formula) will be the same.

Default Contribution Factor (DCF) values are more likely to repeat in a weekly historical period, as different constraints can bind with the week.

Where can I find reason flags for RCR and Usage?

Reason flags for RCR can be found in this section of the data model:
https://nemweb.com.au/Reports/Current/MMSDataModelReport/Electricity/Electricity%20Data%20Model%20Report_files/Elec78.htm#85

Reason flags for Usage can be found in this section of the data model:

https://nemweb.com.au/Reports/Current/MMSDataModelReport/Electricity/Electricity%20Data%20Model%20Report_files/Elec78.htm#121

Why is the Usage or RCR value 'zero'?

The FPP Application may define usage or RCR to zero if the reason flag is set to '1'. A reason flag value of '1' deems the Frequency Measure data as unreliable.

The FPP Application will perform reliability checks once it has calculated the Frequency Measures for a trading interval, which will be applied to both Raise and Lower FMs within the interval. The FPP application will execute three reliability checks on the FM data: minimum number of reliable FM values within an interval, deadband check, and volume of 'bad' raw frequency data within an interval.

Details of each of these can be found in the FPP Factor Calculation guide in Section 5.1: https://aemo.com.au/-/media/files/initiatives/frequency-performance-payments-project/aemo-nem-fpp-factor-calculation-guide.pdf?la=en

Why do some FPP units have a negative contribution factor (CF) value that is different from the NCF value?

Contribution factor (CF) values that are calculated for an FPP unit, where the calculated value is negative, can be different from the Negative Contribution Factor (NCF) value that is calculated for a Requirement (Constraint ID). A negative contribution factor value is indicative of unhelpful performance by an FPP unit for a particular market interval.

For AEMO to recover Used Regulation FCAS costs, Negative Contribution Factors (NCF) will be calculated for a unit in relation to each Regulation FCAS Requirement, for each trading interval.

If Null performance values are found at the time of calculating the NCF, the FPP application will replace the null values with calculated Regulation historical performance values (Section 5.5.4 Substituted Performance in the FPP Factor Calculation Guide). Regulation historical performance will be calculated by capping the unit's real time performance at every five minute trading interval, and then taking the average.

The difference in values between these two fields is a result of substituted performance being used for NCF calculation, i.e. a different set of performance values being used to calculate the NCFs than what was used when calculating the CFs for each FPP unit.

3. Non-financial operation (NFO)

What is FPP NFO?

The extended period of non-financial operation of the new FPP system is intended to allow market participants to familiarise themselves with its operation and see what FPP outcomes would result from actual performance, prior to the commencement of financial flows under the scheme.

NFO is intended to allow participants the opportunity to consider how they might respond to the price signals being produced by FPP, before the new rules take effect. Especially where facilities face poorer financial outcomes under the scheme, they should provide an opportunity for responses to these price signals to be explored before actual financial penalties take effect.

During NFO, the FPP calculation system will be in production. The FPP engine will use actual expected participant dispatch levels and actual performance to produce and report FPP outcomes. However, money will not be settled based on these calculations.

During NFO, Regulation FCAS will also continue to be recovered under the current Causer Pays arrangements.

When is the FPP NFO period?

NFO will begin on 9 December 2024, the day on which the new AEMO systems will be placed in production. The pre-production release for NFO will occurred on 25 October 2024.

Will Causer Pays continue during NFO?

Yes. The current Causer Pays arrangements for the recovery of Regulation FCAS will continue until 8 July 2025, including throughout FPP NFO.

Will FPP outcomes be included on settlement statements during NFO?

No, FPP amounts will not appear on settlements statements during NFO. AEMO is still developing the changes to settlements statements that will be made as part of the FPP reform. This detail will be provided to participants in the Settlements Reports Tech Spec (DM5.4), to be released on 22 September 2024.

Will FPP be separated from Regulation FCAS in settlement statements?

The new PFR/FPP items will be distinct from Regulation FCAS settlement items and will be published in the Settlement Reports distributed to participants. AEMO are still developing the changes to settlement statements and further detail will be provided to participants in the Settlements Reports Tech Spec (DM5.4), to be released on 22 September 2024.

Positive and negative FPP payments will both be listed separately to Reg FCAS in the detailed Settlement Report provided to participants.

How will the NFO data be provided to participants?

During NFO, participants will receive data following each five-minute calculation via Nem Reports (which makes data available in a database for participants to consume). This FPP data reporting functionality will be fully deployed into production before the start of NFO (that is, operating as it will during the system's ongoing operation after full go-live).

At the end of each trading day, data for all participants receiving individual contribution factors, and the residual, will be made publicly available via the NEMWEB portal on AEMO's website (see https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/data-nem/market-data-nemweb).

Will all new FPP tables in the participant data model be populated from the start of NFO?

No. AEMO will not have completed development and testing of the functionality to produce estimates of FPP outcomes by the start of the NFO period. AEMO will communicate about this development and precise target dates via the NEM Reform Program forums (especially the Program Consultative Forum and Implementation Forum).

In particular, tables and data fields that use two weeks of participant performance will not be populated until two weeks after the commencement of NFO (22 December 2024). This effects tables:

- FPP_HIST_PERFORMANCE
- FPP_FORECAST_RESIDUAL_DCF
- FPP_FORECAST_DEFAULT_CF

In addition, the following fields in other tables will not be populated until 22 December:

- UNUSED_FCAS_RATE field in the FPP_EST_PERF_COST_RATE table, and
- UNUSED_FCAS field in the FPP_EST_RESIDUAL_COST_RATE table
- RESIDUAL_DCF field in the FPP_RESIDUAL_CF

Tables providing various FPP estimates and forecasts will be available in production from **mid-February 2025** (and in pre-production by the end of January). These tables are:

- FPP_PD_FWD_EST_RESIDUALRATE
- FPP_PD_FWD_EST_COST
- FPP_P5_FWD_EST_RESIDUALRATE
- FPP_P5_FWD_EST_COST

Will the data published on NEMWeb during the NFO continue to be published on NEMWeb after the FPP Financial Go Live?

Yes.

Will there be a review of the non-financial data during Non-Financial Operation to see how the market is trending?

Yes, AEMO will monitor outcomes closely during NFO. FPP will continue to be a standing item in the NEM Reform forums throughout the implementation and we will share any observations made during this phase, noting that actual behaviour change from participants is not expected to be significant during NFO.

4. Data Model

Has there been any documents released on the differences between 5.4 & 5.5 data models (DM)? Besides the go-live for settlements what are the main differences?

The other changes being made in the EMMS DM5.5 are expected to be for the Enhancing Reserve Information, and Short Term Projected Assessment of System Adequacy (ST PASA) Recall Period changes. The latest information regarding AEMO

DMs and tech specs is available via AEMO's Technical Specification Portal and discussed with participants via AEMO's Market System User Group.

What happens when there are multiple dispatch runs?

Multiple dispatch runs can occur in NEMDE during events when intervals are subjected to Manifestly Incorrect Input (MII) and Over Constrained Dispatch (OCD). This will lead to multiple dispatch outcomes in which there will be files published for each run that has occurred, and error messages may be present. The FPP application will ensure it takes the correct dispatch run file and no action is required from participants.

Where can FPP Public Data be accessed?

Public Market data can be accessed via NEMWEB:
https://visualisations.aemo.com.au/aemo/nemweb/index.html

Frequency Performance Payments data can be accessed via the *Current Reports* link.

Frequency Performance Payments dashboards can be accessed via:

AEMO | FPP data dashboard

5. Timeline

What is the timeline for the delivery of FPP?

Figure 9, below, shows the FPP development and implementation timeline. The new arrangements are being implemented in two stages:

1. Release of the FPP calculation engine, which will take performance measurements from facilities, determine FPP outcomes and report these to facility operators as soon as the calculation is complete. This is referred to as non-financial operation (NFO) because the amounts determined by the FPP process will not be settled.

   NFO commences on 9 December 2024.

2. **Go live of the FPP arrangements is 8 June 2025**, as specified in the National Electricity Rules. FPP outcomes will be settled from this date.

These milestones, as well as the interim steps leading up to them, are outlined above. AEMO will update stakeholders with any changes to the timeline via our regular monthly forums, via electronic correspondence and on the FPP project page on AEMO's website.

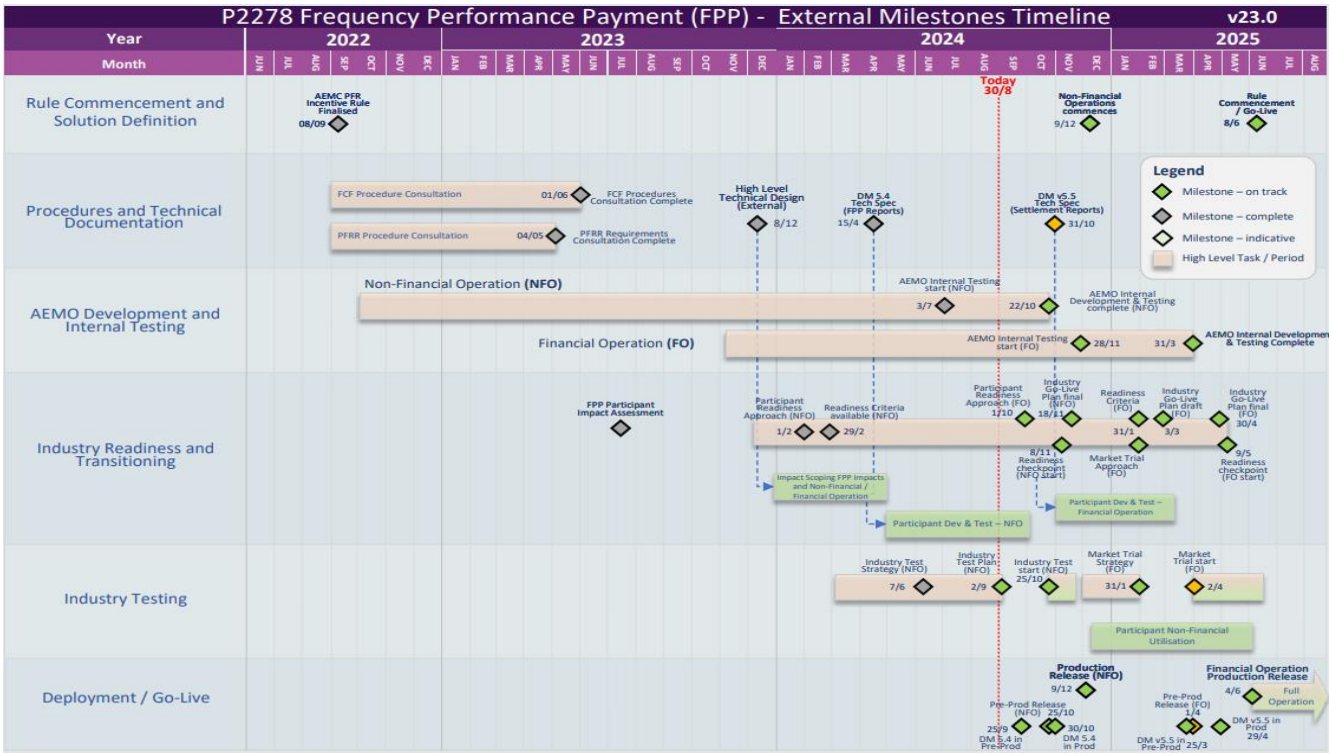

Figure 9 FPP implementation timeline

When will industry testing occur?

There will be two periods of industry testing: one for NFO and one for financial operation.

The first phase of industry testing will commence on 25 October 2024 and run until late November. The precise details will be contained in the Industry Test Strategy and Industry Test Plan, to be released on 7 June 2024 and 2 September 2024, respectively.

The second phase of industry testing is the FPP Market Trial ahead of full go live. The Market Trial is scheduled to commence on 17 March 2025 and run for around two months. The exact parameters of the Market Trial will be specified in the Market Trial Strategy and Market Trial Plan, to be finalised by 31 January 2025 and 9 February 2025, respectively.

The timeline above (Figure 9) includes an Industry Testing swim lane (second from bottom) with further details.

6. Resources and opportunities for engagement

Where can I find more information about the FPP reform?

All AEMO resources related to the FPP reform are accessible on or from the Frequency Performance Payments project page, at https://aemo.com.au/initiatives/major-programs/frequency-performance-payments-project. More information about individual resources available on that page is provided under the next question, below.

All documents related to the AEMC process are available on the Primary Frequency Response Incentives Rule Change page, at https://www.aemc.gov.au/rule-changes/primary-frequency-response-incentive-arrangements.

What other resources are available?

Listed below are selected individual resources that are published on AEMO's FPP project page. Links are provided directly to individual PDFs of other resources.

Resource	Date published	Description
Technical documents		
EMMS Data Model 5.4 Tech Spec	8 December 2023	Technical specification for the Electricity Market Management System (EMMS) Participant Data Model, containing the changes introduced as part of the FPP calculation and performance reporting process.
Frequency Contribution Factor Tuning Parameters and Input Sources	1 June 2023	The Tuning Parameters and Input sources are variables in the FPP calculation process that are specified by AEMO under the FCFP and NER. AEMO has the power to vary these values.
Frequency Contribution Factors Procedure	1 June 2023	The FCFP was developed and published in accordance with NER 3.15.6AA(f). It defines key elements of the FPP calculation process and methodology.
Readiness documents		
Industry Test Strategy	7 June 2024	States that industry testing will be non-coordinated (without designated test scenarios/cases for participants test) and provides other testing-related information.
Readiness Approach and Go-Live Criteria	29 February 2024	Provides go-live criteria at both the high-level and for each element of the approach, as well as additional information.
Industry Readiness Approach	23 January 2024	Provides high-level guidance to the FPP approach to Industry Readiness, including the different elements of the approach.
Presentations		
FPP overview webinar	15 February 2024	This session provided a detailed overview of FPP operations and elements of the calculation process.
FPP Industry impacts and timings workshop	4 September 2023	In this workshop, AEMO presented the expected impacts of the reform to industry stakeholders.
FCFP – Stakeholder technical workshop (reporting)	28 February 2023	This workshop discussed how the data produced by the FPP calculation process would be reported. Now superseded by the High-level technical data design.
FCFP development technical workshop	21 February 2023	An in-depth workshop with stakeholders as part of the development of the FCFP.
Fact Sheets		
Overview of the FPP reform	8 December 2023	Provides a succinct overview of the FPP reforms
FPP calculations and participant outcomes	8 December 2023	Provides a succinct summary of how the FPP calculation process will occur and how the reform will impact different participants.

Resource	Date published	Description
First FPP fact sheet	21 September 2022	Provides some additional background about the origins of the reform not in other fact sheets.
Video explainers		
Forthcoming at time of publication. Available via the FPP project page or AEMO's YouTube channel, https://www.youtube.com/@AEMOenergy		

How can I stay engaged with the implementation of the FPP reform?

As part of the NEM Reform Program, AEMO operates a number of stakeholder forums. The implementation of FPP is regularly discussed at the following open monthly forums:

• **Program Consultative Forum** (see: https://aemo.com.au/consultations/industry-forums-and-workinggroups/list-of-industry-forums-and-working-groups/program-consultative-forum)

• **Implementation Forum** (see https://aemo.com.au/consultations/industry-forums-and-working-groups/listof-industry-forums-and-working-groups/implementation-forum)

• **Electricity Wholesale Consultative Forum** (see https://aemo.com.au/consultations/industry-forums-andworking-groups/list-of-industry-forums-and-working-groups/electricity-wholesale-consultative-forum).

All presentations from previous forums are available on each of the above webpages.

To join the invite list for any of the above forums, email NEMReform@aemo.com.au.

How can I contact AEMO in relation to the FPP reform?

The best way to get assistance on FPP matters is to send your enquiries via email to NEMReform@aemo.com.au. Please send any questions at any time and AEMO's experts will be happy to provide written responses or arrange discussions on any aspect of the reform.

Glossary

Table 1 Glossary

Term	Definition
Cost recovery market participant	Collective term for the different categories of market participants who are subject to the NER. In the case if FPP, primarily generators, bi-directional units (such as energy storage systems) and some loads.
CF (contribution factor)	A factor calculated in respect of, and applied to, an eligible unit with appropriate metering.
DCF (default contribution factor)	A CF calculated and applied to an eligible unit with appropriate metering for either: the allocation of unused Regulation FCAS, or when AEMO is unable to determine an individual factor in a trading interval. Calculated from historical performance over a seven-day period.
DRCF (default residual contribution factor)	A DCF applied to the residual.
Eligible unit with appropriate metering	A generator or large load that will be assigned individual CFs (because it can provide the necessary data).
FM (frequency measure)	The indicator of a need to raise or lower frequency.
FPP (frequency performance payment)	A trading amount payable by, or to, a Cost Recovery Market Participant, determined in accordance with NER.
NCF (negative contribution factor)	A CF that is less than zero.
NRCF (negative residual contribution factor)	A residual contribution factor that is less than zero.
Performance	Collectively refers to Raise Performance and Lower Performance of all units.
PFR	Primary Frequency Response – the initial action by facilities to arrest a deviation in power system frequency.
$P_{regulation}$	The price of Regulation FCAS.
RCF (residual contribution factor)	The contribution factor calculated in respect of, and applied to, the residual.
RCR (requirement for corrective response)	The total volume in MW that contributed to reducing the deviation in frequency of the power system. The RCR is used to scale FPPs and is determined separately for trading amounts for regulating raise services and regulating lower services.
Reference Trajectory	The expected active power output or consumption of an eligible unit with appropriate metering.
Residual	All units without appropriate metering to record four-second unit performance
Residual Deviation	The aggregate deviation of the Residual.
Residual Performance	The aggregate Performance of the Residual.
SCADA	Supervisory control and data acquisition.

Term	Definition
TSFCAS	The total amount of Regulation Raise FCAS or Regulation Lower FCAS in a trading interval.
Usage (U)	The proportion of Regulation FCAS that is deemed to be Used Regulation FCAS,
Unused Regulation FCAS	Regulation FCAS that is deemed to be unused and for which costs are determined in accordance with NER 3.15.6AA(d).
Used Regulation FCAS	Regulation FCAS that is deemed to be Used and for which costs are determined in accordance with NER 3.15.6AA(c).