Economic Regulation Authority

Frequency co-optimised essential system services offer price ceiling determination

Draft report

18 July 2023

Economic Regulation Authority

Level 4, Albert Facey House

469 Wellington Street, Perth WA 6000

Telephone 08 6557 7900

Email info@erawa.com.au

Website www.erawa.com.au

This document can also be made available in alternative formats on request.

National Relay Service TTY: 13 36 77

Invitation to make submissions

Submissions are due by 4:00 pm WST, Tuesday, 15 August 2023

The ERA invites comment on this paper and encourages all interested parties to provide comment on the matters discussed in this paper and any other issues or concerns not already raised in this paper.

We would prefer to receive your comments via our online submission form https://www.erawa.com.au/consultation

You can also send comments through:

Email: publicsubmissions@erawa.com.au
Post: Level 4, Albert Facey House, 469 Wellington Street, Perth WA 6000

Please note that submissions provided electronically do not need to be provided separately in hard copy.

All submissions will be made available on our website unless arrangements are made in advance between the author and the ERA. This is because it is preferable that all submissions be publicly available to facilitate an informed and transparent consultative process. Parties wishing to submit confidential information are requested to contact us at info@erawa.com.au.

For further information please contact

General Enquiries

Irina Stankov
Ph: 08 6557 7998
info@erawa.com.au

Media Enquiries

Danielle Asarpota
Ph: +61 428 859 826
media@erawa.com.au

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Executive summary

From the start of the reformed Wholesale Electricity Market, the current ancillary services arrangements that apply in the South West Interconnected System's WEM will cease to exist and will be replaced with five Frequency Co-optimised Essential System Services (FCESS) markets.[1] The new FCESS are:

- Contingency Reserve Raise and Lower, which replace the spinning reserve and load rejection reserve ancillary services.
- Regulation Raise and Lower, which replace the load following upward and downward ancillary services.
- Rate of Change of Frequency Control Service, which is a new service in the WEM.[2]

In the Real-Time Market, energy and FCESS will be dispatched in a co-optimised manner under security constrained economic dispatch to ensure supply and demand are met for each five-minute dispatch interval, subject to system conditions and constraints. The co--optimisation dispatch process will determine clearing prices in all individual markets which will be used to compensate market participants for the provision of energy and FCESS.[3]

The Economic Regulation Authority will determine FCESS Offer Price Ceiling values for each of the five FCESS markets, setting the maximum price at which market participants can offer in any of the FCESS markets. The first determination will be made before the New WEM Commencement Day. While the ERA must set all five values, over the first five months of the new WEM, the Australian Energy Market Operator will apply a single identical offer price ceiling to all five FCESS markets.[4]

This is the first time the ERA will determine FCESS Offer Price Ceilings for the new markets. The WEM Rules clause 2.26.2B (a) require that the ERA set the offer price ceilings by

> "estimating, consistently with the Offer Construction Guideline as it applies to the highest cost Facility providing the relevant Frequency Co-optimised Essential System Service in the SWIS, the variable costs of providing the Frequency Co-optimised Essential System Service that are not compensated through other market mechanisms in the Wholesale Electricity Market."

In accordance with the requirements of the WEM Rules, the ERA has taken the approach of calculating the first set of FCESS Offer Price Ceilings based on the expected costs of facilities that have been accredited to provide the five FCESS from the New WEM Commencement Day.[5]

The ERA consulted with owners and/or operators of accredited facilities to collect their expected costs, which has informed the ERA's calculation method to determine the highest cost that a facility may incur in providing any of the FCESS. The highest of these costs sets

1 Under the current arrangements, four ancillary services are procured to provide system frequency support. Two are procured through a separate market, and two are subject to administered pricing.

2 The RoCoF Control Service will be provided from the physical inertia of rotating generators. This service is currently received as a by-product of energy production and is not procured through a market mechanism.

3 Compensation for energy will use a 30-minute reference trading price that averages the six five-minute energy market clearing prices over the trading interval. Compensation for FCESS will use the five-minute FCESS market clearing price unless it is higher than the FCESS clearing price ceiling.

4 Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clause 1.60.5, (online).

5 The WEM Rules require facilities that are providing any ancillary services in the current WEM, to accredit and provide at least the equivalent services over the first six months of the new WEM. There are also special obligations for the accreditation of Synergy's facilities. Afterwards, participation will become voluntary.

the FCESS Offer Price Ceiling for each market. Consistent with clause 2.26.2B (b) of the WEM Rules, these values are rounded up to the nearest multiple of $50 per megawatt per hour for the contingency and regulation FCESS, and $50 per megawatt seconds per hour for the RoCoF Control Service.

The estimated FCESS Offer Price Ceiling values for the contingency and regulation FCESS are set at $250/MWh and the RoCoF Control Service is set at $0/MWs per hour. For the first five months of the new WEM, a single offer price ceiling will apply to all five FCESS markets. This single identical value is set at $250/MWh or MWs per hour, as applicable.

The ERA invites market participants and other interested parties to provide feedback and evidence on any aspect of this draft determination. The ERA Secretariat staff are available to hold one-on-one meetings with market participants during the consultation period of this draft determination to explore facility costs and other information that may support the final determination.

1. Background

As part of the market power mitigation strategy in the new Wholesale Electricity Market (WEM), offer price ceilings must be applied to offers submitted in the five Frequency Co--optimised Essential System Services (FCESS) markets. The FCESS Offer Price Ceilings are intended to serve as a backstop for other elements of the market power mitigation framework and are to be set at a level high enough to allow participants to recover efficient costs.[6]

The Economic Regulation Authority will determine the offer price ceilings for the five FCESS markets that will replace the current ancillary services when the new WEM commences and will determine the initial FCESS Offer Price Ceilings before the New WEM Commencement Day.[7]

The five FCESS are:

- Regulation Raise, replacing the current load following upwards service
- Regulation Lower, replacing the current load following downward service
- Contingency Reserve Raise, replacing the spinning reserve service
- Contingency Reserve Lower, replacing the load rejection reserve service
- Rate of Change of Frequency Control Service (there is no equivalent ancillary service in the current market).

The offer price ceilings for each FCESS represent the maximum offer price a market participant may include in a Real-Time Market Submission or a Standing Real-Time Market Submission for the provision of a FCESS from a facility accredited to provide the FCESS.

The market clearing prices for each of the FCESS markets will be determined through co--optimisation with energy in the dispatch engine and is not constrained by the offer price ceilings.[8,9]

As outlined in the ERA's Offer Construction Guideline, FCESS offer prices should include only incremental efficient variable costs that market participants expect to incur when providing a specific FCESS that will not be reimbursed through any other market-based compensation mechanism, including the FCESS Uplift Payment.[10,11]

From the New WEM Commencement Day until the end of the first trading interval on 1 March 2024, the five FCESS Offer Price Ceilings must be a single identical price, which AEMO will

6 Energy Policy WA, November 2022, *Market Power Mitigation Strategy Information Paper*, pp. 14-16, (online).

7 Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clause 1.60.4, (online).

8 Co-optimisation enables generators to offer their full capacity into energy and FCESS markets while remaining commercially indifferent as to which services they are dispatched to provide. This is because the co-optimisation process will, in most cases, consider the opportunity costs of providing FCESS. Refer to section 3.2 of Essential System Services – scheduling and dispatch paper, Energy Transformation Taskforce, 1 December 2019 (online).

9 The WEM Rules include an FCESS Clearing Price Ceiling, which will be applied when the FCESS market clearing price is higher than the FCESS Clearing Price Ceiling.

10 Economic Regulation Authority, June 2023, *Offer Construction Guideline – Draft for consultation*, pp. 8-14, (online).

11 Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2021, clause 9.10.3A, (online).

apply to offers submitted in all five FCESS markets. From 1 March 2024, AEMO will apply the five individual values determined by the ERA to offers in each respective market.[12]

The ERA will review the FCESS Offer Price Ceilings at least once every three years, with the first review to be completed by 1 June 2026. Market participants may also request the ERA to undertake a review, if the market participant considers that there are material changes in market circumstances.[13]

As the FCESS Offer Price Ceilings are determined for a three-year period, the ERA will also consider an indexation process that will apply to each ceiling.[14]

1.1 The ERA's approach

This is the first time that the ERA will make a determination on the FCESS Offer Price Ceilings. The ERA has published this draft report, will allow for 20 business days of public consultation, and will publish a final report prior to the New WEM Commencement Day.

1.1.1 Consultation

The ERA undertook a staged consultation approach for this determination. The initial stage of the consultation process ran from 28 April to 26 May 2023 and consisted of one-on-one meetings with market participants that own and/or operate FCESS accredited facilities, as well as discussions with AEMO and Energy Policy WA. These were then followed by formal data requests to:

- AEMO to provide technical accreditation parameters.
- Owners/operators of accredited facilities to provide FCESS costs information.

The WEM Rules require current ancillary service providers to accredit the facilities that provide any ancillary service in the existing market, prior to the New WEM Commencement Day, and to offer up to the maximum of that accredited capacity in the relevant FCESS market for at least the first six months after New WEM Commencement Day.

In addition, Synergy is specifically required to accredit each of its facilities capable of providing any of the FCESS, including Rate of Change of Frequency Control Service (RoCoF Control Service). The ERA's consultation focused on information that will inform what costs market participants can expect to incur for the facilities that are accredited to provide FCESS.

There are three types of facilities that are expected to provide FCESS: scheduled facilities, semi-scheduled facilities, and interruptible loads. These facilities include thermal generators, electric storage resources, and interruptible loads.[15] Scheduled and semi-scheduled facilities can provide any of the five FCESS, whereas interruptible loads will only provide Contingency Reserve Raise. Different facility types incur different types of costs.

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12 Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2021, clause 1.60.5, (online).

13 Ibid, clauses 1.61.3, 2.26.2N and 2.26.2NA.

14 Ibid, clause 2.26.2B (c).

15 No electric storage facility is accredited at the time this draft report is published, and one interruptible load is currently undergoing the accreditation process.

1.1.2 Cost evaluation

The ERA examined all costs provided by market participants, tested them for consistency with the Offer Construction Guideline which identifies allowable cost components, and developed a calculation method to assess the most expensive provider for each FCESS. Chapter 3 sets out the ERA's process and calculation method.

Once the highest cost provider for each service has been identified based on this facility's cost stack, the ERA determined the offer price ceiling for the respective FCESS. The WEM Rules require that each determined FCESS Offer Price Ceiling value is rounded up to the next $50/MWh or $50/MWs per hour.[16]

1.1.3 Draft determination

This report sets out the ERA's draft determination of the FCESS Offer Price Ceilings and commences the public stage of the consultation process. During the consultation period of this draft determination, the ERA will send a final data request to market participants (final stage of the consultation process) to update technical and financial information previously provided, to assist with the final determination of the FCESS Offer Price Ceilings.

The ERA Secretariat staff are available to consult with interested parties and market participants on the proposed FCESS Offer Price Ceilings throughout the consultation period.

[16] Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clause 2.26.2B (b), (online).

2. The frequency co-optimised essential system services

FCESS replace the existing ancillary services and are needed to maintain security and reliability in the power system. They regulate frequency in real time and in response to contingency events by increasing or reducing output in response to minor and major imbalances between supply and demand.[17] AEMO must procure adequate quantities of FCESS to meet the Essential System Service Standards set out in clause 3.10 of the WEM Rules. AEMO will procure the required FCESS quantities through the five FCESS markets.

2.1 Requirements for facilities to provide FCESS

The WEM Rules require that all facilities that provide any ancillary services in the existing WEM must become accredited and offer the equivalent services in the new FCESS markets. Synergy has specific obligations to consult with AEMO and to accredit all its facilities capable of providing any of the FCESS.[18]

Accreditation for FCESS includes requirements for facilities to meet specific technical arrangements outlined by AEMO in its FCESS Accreditation WEM Procedure.[19] This Procedure describes the performance parameters, communication capabilities, and other requirements a facility must fulfill to become accredited to provide FCESS.

Each facility that seeks accreditation must provide information on its FCESS trapezium for each FCESS. A facility's trapezium is made up of the minimum and maximum enablement levels and the low and high break points. The minimum and maximum enablement levels define the range of the facility's heat rate curve, where the facility is able to provide the relevant FCESS. The low and high break points define the range within the trapezium, where the facility can provide its full accredited FCESS quantity.

2.2 Regulation services

The Regulation service is used to continuously balance supply and demand to maintain frequency within the normal operating bands. Regulation services include increasing or reducing output to manage frequency and are procured through Regulation Raise and Regulation Lower markets respectively.

Regulation services are provided by a facility adjusting its injection or withdrawal following relatively small fluctuations of demand to ensure the system remains within the normal frequency operating band. Regulation Raise operates to raise the system frequency and Regulation Lower operates to lower the system frequency.

Regulation services can be provided by a generator or an electric storage resource.

AEMO will determine the quantity of Regulation Raise and Regulation Lower to be procured in each dispatch interval by taking into account various factors such as the variability of

[17] Contingency events can occur when there is an unplanned and sudden loss of a generating facility, a network element, or a large load, which is outside of AEMO's control.

[18] Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clauses 1.49.1 to 1.49.5, (online).

[19] Australian Energy Market Operator, October 2021, *WEM Procedure: Frequency Co-optimised Essential System Services Accreditation*, (online).

demand, variability of intermittent sources, inherent error in dispatch and the damping effects from droop and system inertia.[20] The Regulation Raise and Regulation Lower quantities are set as input variables into the dispatch algorithm, ensuring that the required quantities are procured from the respective Regulation Raise and Regulation Lower markets to be included in the dispatch algorithm.

FCESS providers will make offers for Regulation Raise and Regulation Lower markets through Real-Time Market Submissions. The dispatch engine will determine which facility is chosen to provide the relevant service based on the offers, system conditions such as constraints, requirements, and other factors.

If there is a shortfall of total quantity offered such that the required Regulation Raise or Regulation Lower quantity cannot be procured from the market, AEMO may issue directions to accredited participants to offer accredited capacity.[21]

AEMO's FCESS Accreditation WEM Procedure requires that offers in the Regulation markets are made at a minimum of 10MW.

2.3 Contingency reserves

Contingency reserve service is separated into Raise and Lower components. The service holds capacity in reserve to rapidly adjust output up or down to maintain frequency within operating standards after a contingency event.

Contingency Reserve Raise requires a facility to increase output in response to under-frequency on the system following the loss of supply.[22] This might occur when a generator or a network asset trip or fail, and the system frequency decreases. This service can be provided by a generator, an electric storge resource, or an interruptible load. Contingency Reserve Raise can be provided by an interruptible load in block response.[23]

Contingency Reserve Lower requires a facility to reduce output in response to over-frequency on the system following the loss of demand. This might occur when a network outage disconnects consumers. This service can be provided by a generator or an electric storge resource.

The contingency reserve services must be sustained for at least 15 minutes following a contingency event on the system.[24]

The dispatch engine uses a Dynamic Frequency Control Model (DFCM) to calculate the Contingency Reserve Raise requirement relative to the quantity of RoCoF Control Service to allow AEMO to maintain system frequency within the credible contingency event frequency band.[25]

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20 Energy Transformation Taskforce, August 2019, *Frequency Control Technical Arrangements – Information Paper*, (online).

21 Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clause 3.11.2, (online).

22 For demand side provision, a load would rapidly reduce demand.

23 Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clause 2.34A.6 (d), (online).

24 Ibid, clause 7.10.18.

25 Energy Transformation Taskforce, December 2019, *Essential System Services – Scheduling and Dispatch – Information Paper*, (online)

The DFCM models system frequency based on different configurations (set of inputs) of the system and includes a matrix that will be used to determine the Contingency raise or lower requirement relative to demand level, the largest contingency, and the level of system inertia.

From the output of the DFCM, for each dispatch interval or pre-dispatch interval, AEMO will calculate a Contingency Reserve Raise and Contingency Reserve Lower Offset, which is a megawatt value that increases or decreases the largest supply and load contingency requirement.[26] At this stage, the dispatch algorithm has been formulated to treat Contingency Lower Offset as zero. Therefore, this parameter has no impact on dispatch outcomes.[27] The contingency requirement is then calculated as the largest contingency less the offset.

The requirements for the Contingency Reserve Raise and RoCoF Control Service will be set as the lowest cost combination of facilities, including limiting the dispatch of facilities to reduce the requirement. AEMO will publish a set of essential systems services system configurations and the associated combination Contingency Reserve Raise and RoCoF Control Service quantities on its website.

The requirement for Contingency Reserve Lower will be set outside the dispatch algorithm and is an input to determining whether security standards are being met.[28]

AEMO's WEM procedure requires that contingency reserve providers offer the services in a minimum of five MW, while block responses must be of a maximum size of 65MW.[29]

2.4 Rate of change of frequency control service

The Rate of Change of Frequency Control Service (RoCoF Control Service) is a new service in the WEM and procures inertia from synchronised generators that must comply with specific requirements.[30,31] The service is measured in megawatt seconds (MWs) and has two functions:

1. Restrict the rate of change of frequency below a defined maximum level.

2. Ensure that minimum frequency requirements are maintained in accordance with the frequency operating standards, reducing the contingency raise requirement.[32]

The WEM Rules define inertia as "the kinetic energy (at nominal frequency) that is extracted from the rotating mass of a machine coupled to the power system to compensate an imbalance in the system frequency." It will be provided as a by-product from the physical rotation of conventional generator turbines. As currently defined in the WEM Rules, inertia cannot be

26 Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clause 7.5.11, (online).

27 Australian Energy Market Operator, October 2023, *Draft WEM Procedure: Dispatch algorithm formulation*, section 2.2.14, p. 14, (online).

28 Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clause 7.5.6, (online).

29 Australian Energy Market Operator, 'Summary of Frequency Co-optimised Essential System Services', (online) – block size here 65MW.

30 Australian Energy Market Operator, October 2021, *WEM Procedure: Frequency co-optimised essential system services accreditation*, section 4.3, p. 24, (online).

31 Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clause 3.9.7, (online).

32 Australian Energy Market Operator, 'Summary of Frequency Co-optimised Essential System Services', (online).

provided by batteries, however, as battery technology matures, an inertia-equivalent service may be able to be reliably provided in the future.

The system inertia allows the system to maintain steady frequency. In the current WEM, inertia is provided without compensation, while in the new WEM it will be procured through the RoCoF Control Service market.

AEMO must schedule and dispatch sufficient Contingency Reserve Raise and RoCoF Control Service to ensure that following a contingency, the frequency is maintained within the relevant frequency bands and the RoCoF Safe Limit. The RoCoF Safe Limit is 0.25Hz over any 500 milliseconds period.[33] The RoCoF Control Service requirement is determined in the DFCM together with the Contingency Reserve Raise requirement.

[33] Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clause 3.10.3 and Appendix 13 Table 1, (online).

3. Determining the highest cost FCESS provider

This section steps out the method the ERA has developed to calculate the FCESS Offer Price Ceilings. The ERA must do this by:

- estimating, consistently with the Offer Construction Guideline as it applies to the highest cost facility providing the relevant FCESS, the variable costs of providing the FCESS that are not compensated through other market mechanisms in the WEM;
- rounding up the value of the FCESS Offer Price Ceiling to the nearest multiple of $50 per MW per hour or $50 per MWs per hour, as applicable; and
- determining whether an indexation process should apply to the FCESS Offer Price Ceiling to reflect movements in input costs and, if so, determining the formula for the indexation calculation and the frequency at which indexation will apply.[34]

The ERA has taken the approach of calculating the first set of FCESS Offer Price Ceilings for the new WEM using the costs of facilities currently accredited to provide FCESS, as opposed to costs of potential new entrants. This is reasonable due to the newness of the FCESS markets and the likelihood that potential new entrants will seek to observe market outcomes before making decisions to participate in the FCESS markets.

At the time this draft determination has been published, multiple generators have been accredited to provide FCESS.[35] No electric storage resource is accredited at this stage, so potential costs of an electric storage resource are not considered in this draft determination. The costs of all the accredited facilities have been used to calculate the FCESS Offer Price Ceilings for this draft determination.

3.1 Data used for draft determination

The WEM Rules enable the ERA to collect data from market participants to use for its functions under these rules.[36] The ERA has collected economic and technical data from market participants in the past to undertake modelling for different projects. This previously collected data and the new accreditation and cost information received during the first consultation period with AEMO and market participants with accredited facilities have been used for this draft determination.

It is recognised that at the time the data request was made, market participants were still developing their cost structures for FCESS provision. Also, at this time the Offer Construction Guideline was not published. Acknowledging this, the ERA's data request was exploratory in nature, seeking to understand the variable costs that market participants expect to incur to provide FCESS.

The ERA published the Offer Construction Guideline on 21 June 2023, providing clarity on costs that the ERA considers may be validly included when constructing an FCESS offer.[37] In making its draft determination, the ERA has maintained consistency with the Offer

[34] Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clause 2.26.2B, (online)

[35] An interruptible load is also expected to accredit for Contingency Reserve Raise provision. At the time of writing, this load had not been accredited.

[36] Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clause 2.16.6, (online).

[37] Economic Regulation Authority, June 2023, *Offer Construction Guideline – Draft for consultation*, (online).

Construction Guideline and recognises that market participants may wish to review the information previously provided to ensure consistency with the Offer Construction Guideline.

For this reason, during the consultation period of this draft determination, the ERA will send another data request under clause 2.16.6 of the WEM Rules, seeking to:

- Update technical and economic data for all accredited facilities. This data request will be consistent with the Offer Construction Guideline, where it relates to FCESS offers.
- Update technical and economic data from all market participants that has been provided in the past.

Once updated information is collected, the ERA will re-calculate the FCESS Offer Price Ceilings for the final determination. The ERA will use the same calculation method, as described in the next sections, and will consider any comments provided by market participant and interested parties as part of the consultation process. For these reasons, the final determination on FCESS Offer Price Ceiling values may differ from the values in this draft determination.

The updated information will also be used to inform the ERA's ongoing market monitoring function for all FCESS markets in the new WEM.

3.2 Consistency with the Offer Construction Guideline

The Offer Construction Guideline provides guidance to market participants on costs that may be included in energy and FCESS offers to be compliant with the requirements of the WEM Rules. The ERA's draft determination on the FCESS Offer Price Ceilings is consistent with the Offer Construction Guideline.

In the new WEM, market participants are expected to include only costs in their Real-Time Market Submissions that a market participant without market power would include in its profit-maximising offers.[38] This principle guides the offers submitted into any of the energy or FCESS markets.

The Offer Construction Guideline provides guidance on what costs are considered efficient variable costs that a market participant without market power is expected to include in its profit-maximising offers. Table 1 in the Offer Construction Guideline lists efficient variable costs components that may be included in Real-Time Market offers. [39]

The efficient variable costs, related to producing the relevant electricity, include variable costs that vary with the level of production, as well as avoidable fixed costs that do not vary with the level of production, but are incurred only when a facility operates for providing a market service.

The incremental efficient variable cost is the change in efficient variable costs that a facility incurs for increasing its production by one unit in a single dispatch interval. The Offer Construction Guideline allows for calculating average operating costs, which is the incremental efficient variable cost calculated over a dispatch cycle that is not necessarily equal to a dispatch interval. This method allows a facility to recover its costs, including start-up costs, over a series of dispatch intervals.

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38 Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clause 2.16A.1, (online).

39 Economic Regulation Authority, June 2023, *Offer Construction Guideline – Draft for consultation*, p. 9, (online).

The Offer Construction Guideline explains how average operating costs may be included when constructing FCESS offers.[40] Market participants may include genuine, justifiable costs they incur when providing a Market Service.

Market participants may not include energy market participation opportunity costs or costs arising from contractual arrangements in Real-Time Market Submissions for FCESS.

- **Opportunity costs**

When making offers in the Real-Time Market, market participants ensure costs at each level of production reflect the true costs of providing any market service. By doing so, facilities are dispatched when the market price is above (or at) its offer prices in most circumstances, ensuring costs are recovered. By offering at cost at all levels of production, the facility would recover its costs and, therefore, be indifferent to being dispatched for energy or FCESS.

- **Contractual arrangements**

In the existing market, market participants may not pass on the costs of contractual arrangements for energy in balancing market offer prices or load following markets offer prices. The same principle applies to the Real-Time Market offer prices for energy and FCESS. Such costs are, therefore, not allowable costs in FCESS offers.

3.3 Calculation method

The ERA has accounted for each accredited facility when calculating the offer price ceilings for each FCESS market. The method below shows the calculation of costs for generators that must participate in the FCESS markets for the first six months. The ERA has reviewed the data provided by the interruptible load facility and concluded it is not the highest cost provider in its respective FCESS market.[41]

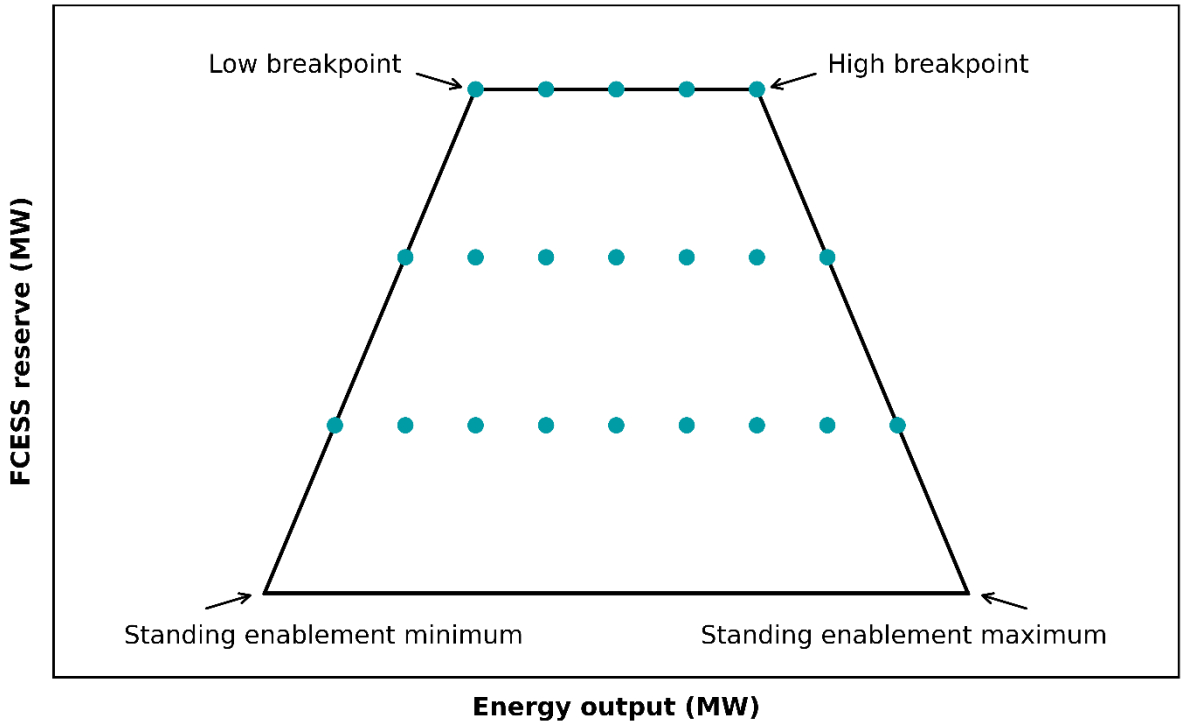
The FCESS Offer Price Ceiling values should be set high enough to allow market participants to recover the efficient variable cost of providing a FCESS for the relevant facility. Each facility has a 'trapezium'', within which it can provide each FCESS, where the height is the FCESS quantity, and the width are the start and end points of the possible provision along its heat rate curve. The low and high break points restrict the area within the facility can provide the maximum accredited capacity of the FCESS.

These parameters are used to work out the cost of providing FCESS anywhere within the trapezium. The ERA calculation method considers the largest of the costs of the facility with the highest cost for each FCESS, and the offer price ceiling is then equal to the highest of all the facility costs.

[40] Economic Regulation Authority, June 2023, *Offer Construction Guideline – Draft for consultation*, pp. 43-45, (online).

[41] The ERA reviewed and considered the costs provided by the interruptible load for provision of Contingency Reserve Raise, although, the accreditation process of the interruptible load is not completed yet.

Figure 1. Example of a FCESS trapezium



Source: ERA model

When calculating each FCESS Offer Price Ceiling, the ERA model has constructed FCESS offers that account for costs consistent with the Offer Construction Guideline. These include:

- Costs associated with change in fuel consumption
- Start-up costs
- Other avoidable fixed costs
- Additional wear and tear costs (Regulation only).[42]

3.3.1 Change in fuel costs

A change in fuel costs can occur when a facility must generate at a lower level to have sufficient head room to provide FCESS. Fuel costs increase, when moving to a less efficient point on a facility's heat rate curve, where the facility consumes more fuel to produce energy. While this higher fuel cost is not recoverable in an energy offer, the change in fuel costs may be recovered through an FCESS offer.[43]

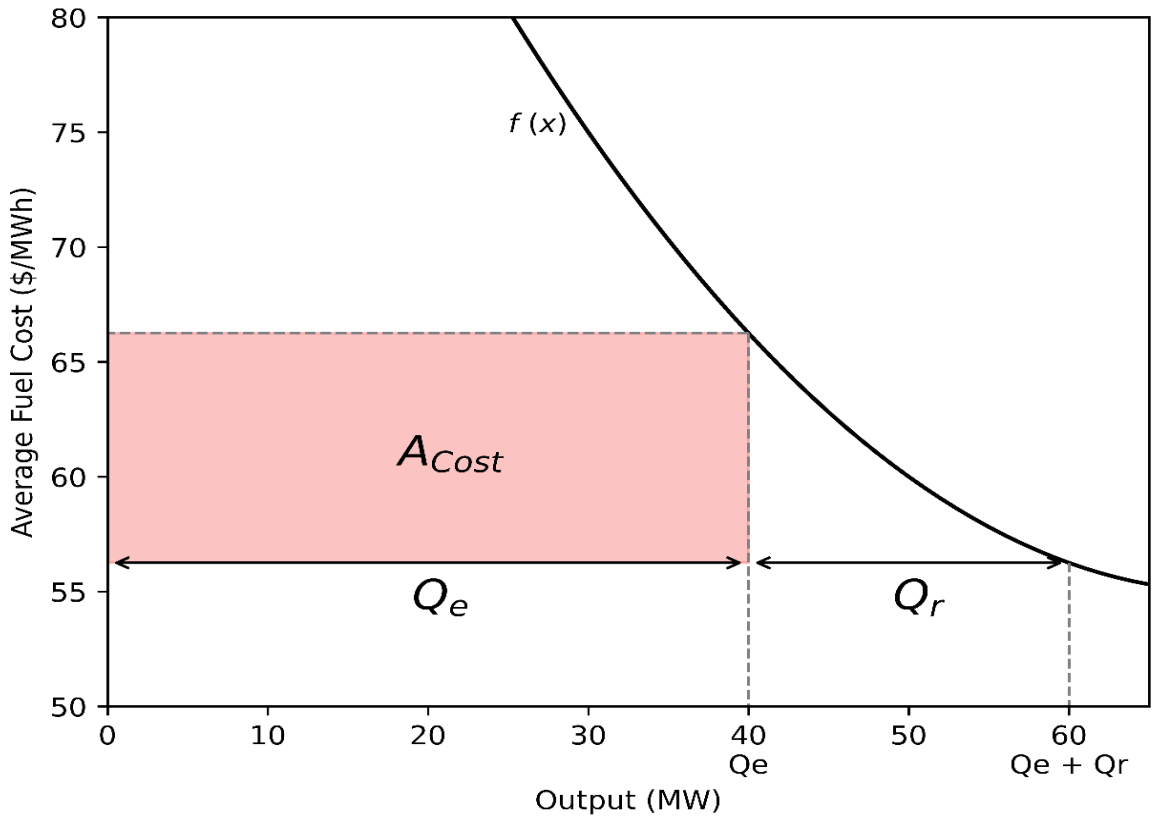
Figure 2 below shows f(x), which is the average fuel cost for each MW of output, where:

average fuel costs ($/MWh) = heat rate (GJ/MWh) * fuel price ($/GJ) / output (MW)

[42] The Contingency Reserve service is an availability service, i.e., facilities are held at a specified output level to provide a raise or lower service, if a contingency event occurs. Therefore, the calculation method does not consider additional wear and tear costs for these services.

[43] At a lower level of production, the facility is typically less efficient and avoidable fixed costs are spread over a smaller quantity. Therefore, its production costs are higher. This is in contrast to the requirement of the WEM Rules to offer energy and/or FCESS in a monotonically increasing manner.

Figure 2. Change in average fuel cost



Source: ERA model

Figure 2 shows the additional fuel costs that can be incurred from holding back output to provide a Raise service. The area labelled A_{Cost} represents the total additional fuel cost from lowering the facilities output from 60MW to 40MW. If the facility did not provide FCESS and ran at 60MW the fuel costs per megawatt would be lower. The facility is entitled to get compensation for this change in fuel costs for the 40MW of output it could be constrained down to.

Q_e = energy quantity (MW).

The energy quantity is the amount of energy a facility has cleared for, that is not reserved for FCESS.

Q_r = reserve quantity (MW).

The reserve quantity is the amount of energy a facility has cleared for an FCESS.

For example, a facility might be at a starting output of 100MW with 20MW reserved to provide Regulation Lower. In this example the facility's output quantities would be:

Q_e = 80MW and Q_r = 20MW.

If the facility was reserving a quantity to provide Regulation Raise instead, its output quantities would be:

Q_e = 100MW and Q_r = 20MW

$avg\ fuel\ cost(Q_e)$ is the average fuel cost for each MWh as described above, at a specific output level of Q_e

Change in average fuel costs may be calculated as shown below:

Equation 1:

This equation shows how to calculate the area of A_{Cost} displayed in Figure 2, which is the total increase in fuel costs for an output of Q_e MW and a reserve of Q_r.

$$A_{Cost}(Q_e, Q_r) = (avg\ fuel\ cost(Q_e) - avg\ fuel\ cost(Q_e + Q_r)\ ) * Q_e$$

Equation 2:

The total change in fuel costs per MW of reserve is:

$$C = \frac{A_{Cost}}{Q_r}$$

This is the amount that will compensate total change in fuel costs if included in the FCESS offer.

The A_{Cost} in Equation 1 is the highest possible total increase in fuel costs incurred by the facility when providing Q_r MW of reserve.

C in Equation 2 is the highest cost possible that a facility may incur, averaged for each MW of reserve provided and is used in cost recovery. During settlement, the facility is paid the FCESS clearing price multiplied by the quantity of reserve provided.

3.3.2 Start-up costs

The start-up costs used in this FCESS Offer Price Ceiling draft determination are derived from information provided by market participants through previous data collections. These are 'smeared' over short runtimes, which are based on AEMO's SCADA data over a three-year period. The SCADA data is used to construct a distribution of historical facility dispatch cycle run times, where a 5% quantile (from the left) from the runtime distribution is used as the facility's short runtime.

Start-up costs are calculated by dividing the static start-up cost of a facility by its short runtime and output Q_e (MW), in other words, the total amount of MWh the facility outputs during a short runtime.

3.3.3 Other avoidable fixed costs

Other avoidable fixed costs consist of non-sunk costs that are only incurred when a facility is running and are independent of the load. The cost per hour is then divided by the output Q_e (MW).

3.3.4 Wear and tear costs

Wear and tear costs are a static cost provided by a facility added to the total costs. These costs are only applied for Regulation services. For the calculation of the Regulation offer price ceilings, the same wear and tear cost was used for each facility, due to limited data availability at time the calculation method was developed for this draft determination.[44]

3.3.5 Applied calculation method

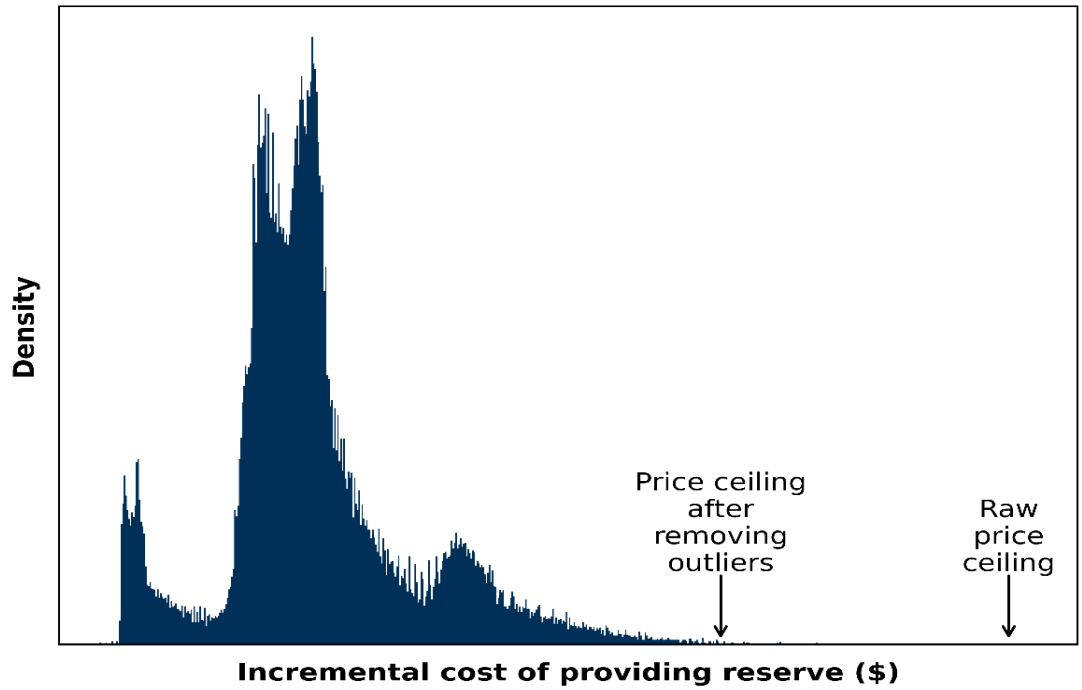
The calculation method for the offer price ceilings uses each facility's trapezium for each FCESS to find the highest costs when providing the respective FCESS.[45] In Figure 1 there are multiple points on the trapezium. These points were considered for the offer price ceilings, where each point in the trapezium has a calculated aggregated cost, which includes the change in average fuel costs, start-up costs, avoidable fixed costs and wear and tear costs.

These points give an array of potential costs a facility may incur when providing the relevant FCESS. From this array, 0.03% of the highest costs are removed to deal with outlying data points that may skew the offer price ceiling calculation (Figure 3). The maximum cost in the new array is the facility's highest cost point. The highest cost of all facilities is then used to set the FCESS Offer Price Ceilings for Regulation and Contingency Reserve services.

[44] The ERA will collect more detailed data from accredited market participants to ensure the final determination is based on the most up-to-date costs for each individual facility.

[45] A facility can provide up to five different FCESS, which could result in it having up to five different trapezia.

Figure 3. Frequency distribution of facility costs for reserve



Source: ERA model

When providing RoCoF Control Service, a generator needs to be already dispatched for energy, as RoCoF Control Service is the inertia output of a generator while it is producing energy. A facility providing energy is, therefore, not expected to incur any additional costs when providing RoCoF Control Service and would be expected to recover any costs through its energy offers.

3.4 Indexation

In accordance with the WEM Rules, the ERA will consider whether an indexation should apply to the FCESS Offer Price Ceilings to reflect movements in input costs, and if so, determining the formula for the indexation calculation and the frequency at which indexation will apply.[46]

The indexation process would allow updating the offer price ceilings at regular time intervals, to adjust input costs to reflect various factors driving market participants' FCESS offers, without the need to review the offer price ceilings more frequently than every three years, subject to no material changes in market circumstances.

The ERA considers it reasonable to index the FCESS Offer Price Ceilings by the Consumer Price Index (CPI) for Perth, published quarterly by the Australian Bureau of Statistics.[47] The CPI measures price increases in a basket of goods and services purchased by households and generally represents price shifts in the economy that the ERA expects would impact market participants.

[46] Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clause 2.26.2B (c), (online).

[47] Australian Bureau of Statistics, Consumer Price Index, Australia. Series id: A2325826V (Perth), (online).

The ERA is also considering other suitable indices or escalation factors for its final determination and is seeking the views of market participants and other interested parties on this matter. [48]

Where there are material changes in market circumstances, such as a new technology entering any of the FCESS markets, the ERA may decide to review any or all of the FCESS Offer Price Ceilings to ensure they continue to represent the costs of the highest-cost FCESS provider. Additionally, market participants may request the ERA to review an FCESS Offer Price Ceiling, if they consider material changes in market circumstances have occurred.[49]

[48] Other potential indices could be the producer price index or a relevant fuel indexation.

[49] Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clauses 2.26.2N and 2.26.2NA, (online).

4. Draft determination

This section provides the ERA's values for the draft determination on the FCESS Offer Price Ceilings that will apply from the New WEM Commencement Day. The ERA determines the FCESS Offer Price Ceilings for all five FCESS, being Contingency Reserve Raise and Lower, Regulation Raise and Lower and the RoCoF Control Service.

The ERA used the calculation method described in section 3.3 to derive the highest cost from 99.7% of the facilities' costs to determine the highest cost an FCESS providing facility can be expected to incur for each of the FCESS. The differentiation in the individual FCESS Offer Price Ceiling values is somewhat masked because of the WEM Rules requirement to round up to the nearest multiple of $50/MWh or $50/MWs per hour. This has resulted in offer price ceilings for four out of five of the FCESS to be the same.

The WEM Rules require that for the first five months from the New WEM Commencement Day, the ERA determines a single identical price to apply to all five FCESS markets.[50] These values are set out in the first row of Table 1, while the second row reflects the individual FCESS Offer Price Ceilings for each FCESS that will apply from 1 March 2024.

Table 1: FCESS Offer Price Ceilings and commencement dates

	Contingency Reserve Raise	Contingency Reserve Lower	Regulation Raise	Regulation Lower	Rate of Change of Frequency Control Service
FCESS Offer Price Ceiling to apply from New WEM Commencement Day	$250/MWh				$250/MWs per hour
FCESS Offer Price Ceiling to apply from 1 March 2024	$250/MWh	$250/MWh	$250/MWh	$250/MWh	$0/MWs per hour

Source: ERA modelling

[50] Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clause 1.60.5, (online).

Appendix 1 List of Tables

Appendix 2 List of Figures

Appendix 3 Compensation mechanism and worked examples

While FCESS Offer Price Ceilings will be set to enable the highest-cost facility providing FCESS to recover its efficient variable costs, market participants are expected to construct their offers in a way to meet their offer obligations under the WEM Rules.

The FCESS offers should be constructed in a way that will allow market participants to recover the individual facility's efficient costs over a given dispatch cycle, in accordance with the Offer Construction Guideline and the Trading Conduct Guideline.[51] Any other bidding behaviour would be inconsistent with these Guidelines and in breach of the WEM Rules and could trigger investigation by the ERA.

Compensation for FCESS provision

Facilities providing FCESS in any dispatch interval should be able to receive full compensation for the efficient variable costs of providing the FCESS, where such costs are not compensated through other market-based mechanisms.

Depending on the type of facility providing FCESS, compensation will be received through:

- Payment for the energy produced as measured by the facility's metered schedule[52]
- FCESS enablement payment[53]
- FCESS Uplift Payment.[54]

Where offers are constructed in accordance with the Offer Construction Guideline, all efficient variable costs of providing FCESS will be fully compensated.

Energy payment

Scheduled and semi-scheduled facilities will receive a payment for their energy output as measured by their metered schedule multiplied by the reference trading price for the trading interval.[55]

For a facility that is held in reserve to provide or be enabled for a raise or lower service, the energy settlement amount will compensate for the actual energy produced, which would include the quantity produced to reach its minimum enablement level and/or any other quantity that the facility may already be producing within its FCESS trapezium.

51 Economic Regulation Authority, June 2023, *Offer Construction Guideline – Draft for consultation*, (online), and Economic Regulation Authority, June 2023, *Trading Conduct Guideline – Draft for consultation*, (online).

52 Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clause 9.9, (online).

53 Ibid, clause 9.10.

54 Ibid, clauses 9.10.3A to 9.10.3O.

55 The reference trading price for a 30-minute trading interval is the average of the six five-minute energy market clearing prices calculated for each dispatch interval in that trading interval.

FCESS enablement payment

A facility providing or enabled for a FCESS receives compensation based on the FCESS enablement quantity multiplied by the FCESS market clearing price. The dispatch engine will calculate the FCESS market clearing prices for each FCESS for each dispatch interval. The co-optimisation algorithm clears energy and FCESS simultaneously, accounting for complex trade-offs between energy and FCESS provision and ensuring that the opportunity cost for reserving FCESS quantities is reflected in the FCESS market clearing price.[56]

FCESS Uplift Payment

The FCESS Uplift Payment will compensate a facility's start-up costs and minimum running costs up to the facility's minimum enablement level, if the facility is needed to provide FCESS but otherwise not required for energy.[57] This recognises that the FCESS market clearing price may not fully compensate the costs of starting an otherwise offline facility to provide only FCESS.

Only scheduled and semi-scheduled facilities are eligible for FCESS Uplift Payments, and the uplift payment for a facility and dispatch interval is the maximum of the enablement losses for all FCESS provided by this facility in that dispatch interval.[58] The enablement losses estimate the difference between the revenue a facility is expected to receive for the provision of energy and FCESS and the cost of providing these services.[59]

There may be situations when a facility is needed only to provide a FCESS, but otherwise not needed for energy. In such cases, the facility must ensure that it is synchronised and ready to be dispatched for FCESS by the start of the relevant dispatch interval, and the relevant market participant must update its offers to shift the required capacity from available to in-service for the relevant dispatch interval.

The facility must ramp up to reach its minimum enablement level for the relevant FCESS for the dispatch interval it is expected to be needed. During the ramp up time the facility may choose to bid below costs to reach its required level of operation, but is expected to price its offers at cost for the minimum enablement level once it reaches its FCESS trapezium.

Once the facility has reached its trapezium, it should offer its quantity at cost and will be reimbursed through the energy market, the FCESS market and where applicable, it will receive an FCESS Uplift Payment.

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56 The new WEM design includes an FCESS Clearing Price Ceiling which, for a dispatch interval is equal to Energy Offer Price Ceiling minus Energy Offer Price Floor plus the respective FCESS Offer Price Ceiling. Where an FCESS market clearing price is excessively high, the FCESS Clearing Price Ceiling will cap the total FCESS compensation per MWh payable to a facility.

57 The enablement minimum can be different from the facility's minimum stable generation level.

58 Consolidated companion version of the *Wholesale Electricity Market Rules (WA)*, 29 April 2023, clauses 9.10.3H to 9.10.3O, (online).

59 Ibid, clauses 9.10.3C to 9.10.3G.

Example for provision of a Lower service

This simplified example is to demonstrate how the FCESS clearing price will be derived and how facilities will recover their provision costs and does not consider network or other system constraints. In this example it is assumed that generators bid at cost.

The example does not aim to replicate WEMDE dispatch outcomes, but rather validate the expectation that under most circumstances facilities will be fully reimbursed.

Table 2: FCESS Lower service

Requirement	Quantity	Unit
Energy demand	275	MW
FCESS Lower demand	55	MW

Market price limits	Floor	Ceiling
Energy market	$-1,000/MWh	$800/MWh
FCESS Lower offer price ceiling ($/MWh)	$0/MWh	$250/MWh

Facility parameter	A	B	C
Status	In-Service	In-Service	In-Service
Min gen = min enablement level (MW)	50	140	10
Maximum capacity (MW)	140	200	110

Offer	A	B	C
Energy Price-Quantity Pair 1			
Quantity (MW)	90	175	110
Price ($/MWh)	$100	$110	$450
Cost ($/MWh)	*$100*	*$110*	*$450*
Energy Price-Quantity Pair 2			
Quantity (MW)	50	25	0
Price ($/MWh)	$125	$113	$0
Cost ($/MWh)	*$125*	*$113*	*$0*
FCESS Lower Price-Quantity Pair			
Quantity (MW)	25	25	30
Price ($/MWh)	$1	$1.5	$3

Offer	A	B	C
Cost ($/MWh)	*$1*	*$1.5*	*$3*

Dispatch and prices	A	B	C
Dispatch			
Energy (MW)	90	170	15
FCESS Lower (MW)	25	25	5
Total system cost per h	$34,528		
Energy price ($/MWh)	$110	*Next MW will come from B*	
FCESS Lower price ($/MWh)	$343	*Next MW will come from C, with reduction of 1 MW from B for energy*	

Actual energy dispatch from P-Q pair	A	B	C
Q1 (MW)	90	170	15
P1 ($/MWh)	*$100*	*$110*	*$450*
Q2 (MW)	0	0	0
P2 ($/MWh)	*$125*	*$113*	*$0*

Cost to provide all services:

Total cost = 90*$100+25*$1+170*$110+25*$1.5+15*$450+5*$3 = $34,528

If energy demand is to increase by 1MW, it can be sourced from P-Q Pair 1 of generator B, therefore, the energy clearing price is $110/MWh.

If FCESS Lower demand is to increase by 1MW, it can only be sourced from generator C, as the FCESS offers of generators A and B are fully utilised. As it is a lower service, increasing the provision of FCESS by generator C by 1 MW means that it also must increase its energy generation by 1MW, and 1MW of energy must be reduced from another facility.

In this case the reduction can come from generator B, as it is the more expensive generator. The updated total cost is shown below:

Total cost = 90*$100+25*$1+169*$110+25*$1.5+16*$450+6*$3 = $34,871

The incremental cost for providing 1MW additional FCESS Lower results in a FCESS Lower clearing price of:

FCESS clearing price = $34,871 - $34,528 = $343/MWh

Generator A and B are needed to provide energy, however, generator C is very expensive and is needed only to provide FCESS. This generator will receive a FCESS Uplift Payment in addition to energy and FCESS market revenues, which will allow it to recover all its costs.

Financial outcomes for each generator are shown in the table below.

Cost/revenue	A	B	C
Facility cost	$9,025.00	$18,737.50	$6,765.00
Facility revenue (energy)	$9,900.00	$18,700.00	$1,650.00
Facility revenue (FCESS Lower)	$8,575.00	$8,575.00	$1,715.00
FCESS Uplift Payment	$0.00	$0.00	$3,400.00
Profit/loss (sum of revenues – cost)	$9,450.00	$8,537.50	$0.00

The FCESS Uplift Payment is the difference between generator's C cost less the energy clearing price times the enablement minimum for this facility and is calculated as:

FCESS Uplift Payment (gen C) = ($450-$110) * 10 = $3,400

Example for provision of a Raise service

This simplified example is to demonstrate how the FCESS clearing price will be derived and how facilities will recover their provision costs and does not consider network or other system constraints. In this example it is assumed that generators bid at cost.

The example does not aim to replicate WEMDE dispatch outcomes, but rather validate the expectation that under most circumstances facilities will be fully reimbursed.

Table 3: FCESS Raise service

Requirement	Quantity	Unit
Energy demand	220	MW
FCESS Raise demand	55	MW

Market price limits	Floor	Ceiling
Energy market	$-1,000/MWh	$800/MWh
FCESS Raise offer price ceiling ($/MWh)	$0/MWh	$250/MWh

Facility parameter	A	B	C
Status	In-Service	In-Service	In-Service
Min gen = min enablement level (MW)	50	150	10
Maximum capacity (MW)	140	200	110

Offer	A	B	C
Energy Price-Quantity Pair 1			
Quantity (MW)	50	150	110
Price ($/MWh)	$100	$110	$450
Cost ($/MWh)	*$100*	*$110*	*$450*
Energy Price-Quantity Pair 2			
Quantity (MW)	90	50	0
Price ($/MWh)	$125	$113	$0
Cost ($/MWh)	*$125*	*$113*	*$0*
FCESS Raise Price-Quantity Pair			
Quantity (MW)	25	25	30
Price ($/MWh)	$1	$1.5	$3
Cost ($/MWh)	*$1*	*$1.5*	*$3*

Dispatch and prices	A	B	C
Dispatch			
Energy (MW)	50	160	10
FCESS Raise (MW)	25	25	5
Total system cost per h	$27,208		
Energy price ($/MWh)	$113	*Next MW will come from B's second P-Q Pair*	
FCESS Raise price ($/MWh)	$3	*Next MW will come from C*	

Actual energy dispatch from P-Q pair	A	B	C
Q1 (MW)	50	150	10
P1 ($/MWh)	*$100*	*$110*	*$450*
Q2 (MW)	0	10	0
P2 ($/MWh)	*$125*	*$113*	*$0*

Cost to provide all services:

Total cost = 50*$100+25*$1+150*$110+10*$113+25*$1.5+10*$450+5*$3 = $27,208

If energy demand is to increase by 1MW, it can be sourced from P-Q Pair 2 of generator B, therefore, the energy clearing price is $113/MWh.

If FCESS Raise demand is to increase by 1MW, it can only be sourced from generator C, as the FCESS offers of generators A and B are fully utilised. As it is a raise service, increasing the provision of FCESS by generator C by 1 MW means that there is no need to change the energy dispatch of any of the generators, as they are held back to generate at a lower level to provide head room.

The updated total cost is shown below:

Total cost = 50*$100+25*$1+150*$110+10*$113+25*$1.5+10*$450+6*$3 = $27,211

The incremental cost for providing 1MW additional FCESS Raise results in a FCESS Raise clearing price of:

FCESS clearing price = $27,211 - $27,208 = $3/MWh

Generator A and B are needed to provide energy, however, generator C is very expensive and is needed only to provide FCESS. This generator will receive a FCESS Uplift Payment in addition to energy and FCESS market revenues, which will allow it to recover all its costs.

Financial outcomes for each generator are shown in the table below.

Cost/revenue	A	B	C
Facility cost	$5,025.00	$17,667.50	$4,515.00
Facility revenue (energy)	$5,650.00	$18,080.00	$1,130.00
Facility revenue (FCESS Raise)	$75.00	$75.00	$15.00
FCESS Uplift Payment	$0.00	$0.00	$3,370
Profit/loss (sum of revenues – cost)	$700.00	$487.50	$0.00

The FCESS Uplift Payment is the difference between generator's C cost less the energy clearing price times the enablement minimum for this facility and is calculated as:

FCESS Uplift Payment (gen C) = ($450-$113) * 10 = $3,370