Real-Time Market Insights Forum

12 December 2023

Hosted by the WA Real-Time Market Monitoring Team

Please send questions, feedback and ideas to:
wa.rtm@aemo.com.au

Disclaimer

This material provides general information about the operation of the Western Australian Wholesale Electricity Market (WEM).

The information may be subject to specific exceptions or may not apply to particular circumstances.

To fully understand their obligations, participants should refer to the WEM Rules and WEM Procedures.

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AEMO Competition Law & Meeting Protocol

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Participants in AEMO discussions **must**:

- Ensure that discussions are limited to the matters contemplated by the agenda for the discussion
- Make independent and unilateral decisions about their commercial positions and approach in relation to the matters under discussion with AEMO
- Immediately and clearly raise an objection with AEMO or the Chair of the meeting if a matter is discussed that the participant is concerned may give rise to competition law risks or a breach of this Protocol.

Participants in AEMO meetings **must not** discuss or agree on the following topics:

- Which customers they will supply or market to
- The price or other terms at which Participants will supply
- Bids or tenders, including the nature of a bid that a Participant intends to make or whether the Participant will participate in the bid
- Which suppliers Participants will acquire from (or the price or other terms on which they acquire goods or services)
- Refusing to supply a person or company access to any products, services or inputs they require.

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Agenda

#	Time	Item	Speaker
1	13:00	Review of RTM Suspension Framework	Rick Dolling
2	13:10	Binding Network Constraints	Sophie Burgess
3	13:20	Pinjar Unit Constraints	Adrian Pearce
4	13:25	Capacity Cost Refunds	Madison Pigliardo
5	13:45	Market Clearing Price Comparisons	Damian Mugridge
6	13:50	WEMDE Deployment Overview	Douglas Birse
7	14:00	Questions, Feedback, Ideas	Attendees

Review of RTM Suspension Framework

Presenter	Rick Dolling
Purpose	Review of the Real-Time Market Suspension framework, as previously communicated in ITF and WRIG.

WEMDE Failure States

Background: WEMDE may fail to calculate accurate Market Schedules due to a number of reasons:

- Inability to complete a calculation due to supporting IT infrastructure failure or performance degradation.
- Material inaccuracy / reduced confidence in the calculation due to manifest errors in input data from upstream systems.

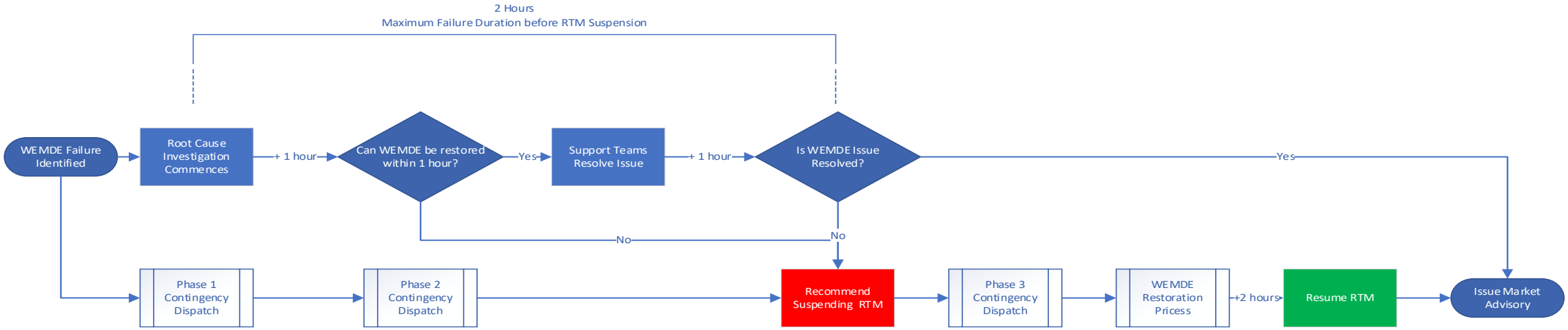
In both cases, the length of time the failure extends, conditions of the power system and availability of energy and ESS services will dictate AEMO's operational response to the event.

Phase 1 (Intermittent)	Phase 2 (Temporary)	Phase 3 (Extended)
• The most common failure state is an **intermittent** failure of WEMDE resulting in a short disruption to its ability to calculate Market Schedules. • Phase 1 extends immediately from a WEMDE failure up to the point AEMO is required to issue Directions to manage power system security. • During this failure state Market Participants are expected to remain at their last issued Dispatch Instruction (DI) and continue submission of RTMS.	• **Temporary** failure of WEMDE occurs when investigation is required to solve the underlying failure. • Phase 2 therefore extends from the point Directions are required based on a suitable Dispatch / Pre-Dispatch Schedule to manage the required energy and ESS enablement, up until the point it is not longer viable to operate the power system using this method as it significantly impacts market settlement. • AEMO may enable additional ESS as required to maintain power system security.	• A WEMDE failure may last for an **extended** period due to major IT infrastructure issues, or coordinated investigation required into erroneous solutions. • Phase 3 commences when AEMO can no longer use the last available Dispatch / Pre-Dispatch schedule to issue Directions for energy, ESS and commitment as it will significantly impact market settlement. • **When entering this phase AEMO will suspend the Real-Time Market.**

Suspension Considerations

Under Phase 2, AEMO will begin issuing directions that diverge from the latest Market Schedules, which will start impacting market settlement. The WEM Rules allow AEMO to suspend the RTM in situations where "…in its reasonable opinion, that actions undertaken to maintain Power System Security and Power System Reliability are significantly impacting market settlement…".
AEMO considers that a time limit between a WEMDE failure and Market Suspension is the most consistent way to apply the suspension rules. Specifically, AEMO will:

- Immediately escalate a WEMDE failure to the relevant IT support teams for investigation.
- Within 1 hour from failure, if the root cause cannot be determined or the AEMO does not believe they can resolve the issue AEMO may recommend to suspend the RTM (this may occur at any point within the initial 1 hour).
- If the root cause has been identified and it can be resolved within 1 hour AEMO will not recommend to suspend the RTM and remain in Phase 2 (maximum 2 hours in Phase 2).
- AEMO may recommend to suspend the RTM if the issue is not resolved within 2 hours even if resolution processes are ongoing.
- Decision to suspend will be based on recommendation and reasonable opinion that actions are significantly impacting market settlement in accordance with the provisions of the WEM Rules
- AEMO will review and update the RTM Suspension trigger and processes as required.

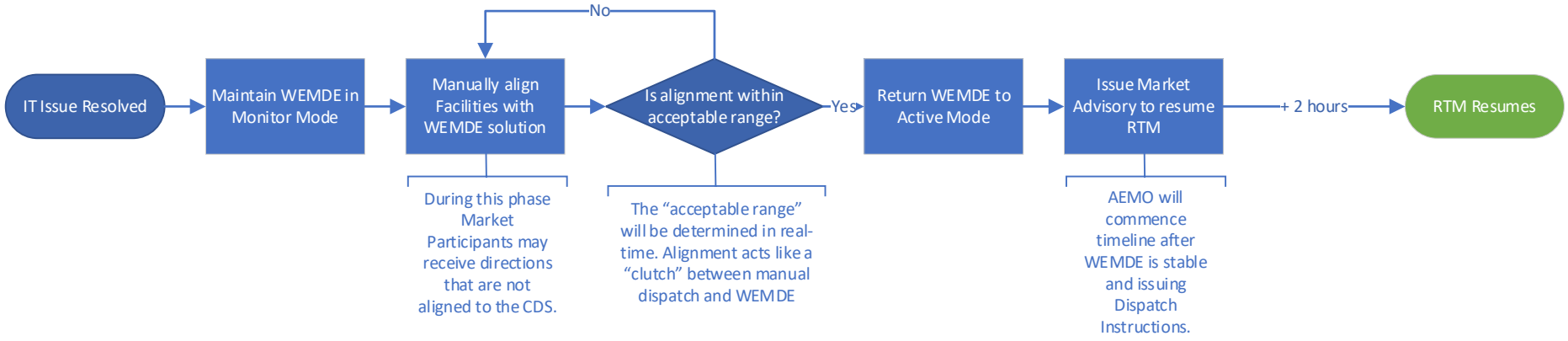


WEMDE Restoration Process

The WEMDE Restoration Process is initiated once the Contingency Management Team have deemed WEMDE to be in a stable state. The process that follows is:

Key steps in this process include:

1. Running WEMDE in “monitor mode”, i.e. a solution is being generated but no Dispatch Instructions are issued.
2. The WEMDE solution is validated against current facility set-points and AEMO start issuing Directions to align these set-points to the WEMDE solution.
3. Once appropriately aligned, WEMDE is move to active mode.
4. Continually monitor WEMDE solution integrity (BAU) on an ongoing basis.
5. Stand down Contingency Management Team.



Lifting Market Suspension

AEMO must provide at least a 2 hours lead time to resume the RTM from a suspended state [7.11D.3(a)(i)], commencement of this timeline will be confirmed via Market Advisory. In practice AEMO will not resume the RTM until AEMO systems are stable and active (issuing Dispatch Instructions) to avoid subsequent suspension if issues arise during the WEMDE Restoration Process.

WEMDE Restoration Process

Operating State:	Emergency
Details:	Further to Market Advisory 00000, AEMO has resolved the IT system issue impacting the ability of the WEM Dispatch Engine to produce Market Schedules and has commenced the WEMDE Restoration Process.
Action AEMO will take:	Complete the WEMDE Restoration Process and advise Market Participants when AEMO has recommenced using the WEM Dispatch Engine to manage the Central Dispatch Process.
Action MP and NO must take:	Follow all Dispatch Instructions issued by AEMO.
Action MP may take:	Please call AEMO on 1300 989 797 (Option 1) if further information is required.

Incident Closure

Operating State:	Normal
Details:	Further to Market Advisory 00000, AEMO has completed the WEMDE Restoration Process, the WEM Dispatch Engine is active. The Real-Time Market will resume in 2 hours in accordance with clause 7.11D.3 of the WEM Rules.
Action AEMO will take:	AEMO has recommenced using the WEM Dispatch Engine to manage the Central Dispatch Process. AEMO will resume the Real-Time Market in 2 hours.
Action MP and NO must take:	Follow all Dispatch Instructions issued by AEMO.
Action MP may take:	Please call AEMO on 1300 989 797 (Option 1) if further information is required.

+ 2 Hours

Resume RTM

Binding Network Constraints

Presenter	Sophie Burgess
Purpose	Provide Market Participants information on how to access and understand binding Network Constraints, Facilities included and provide an example.

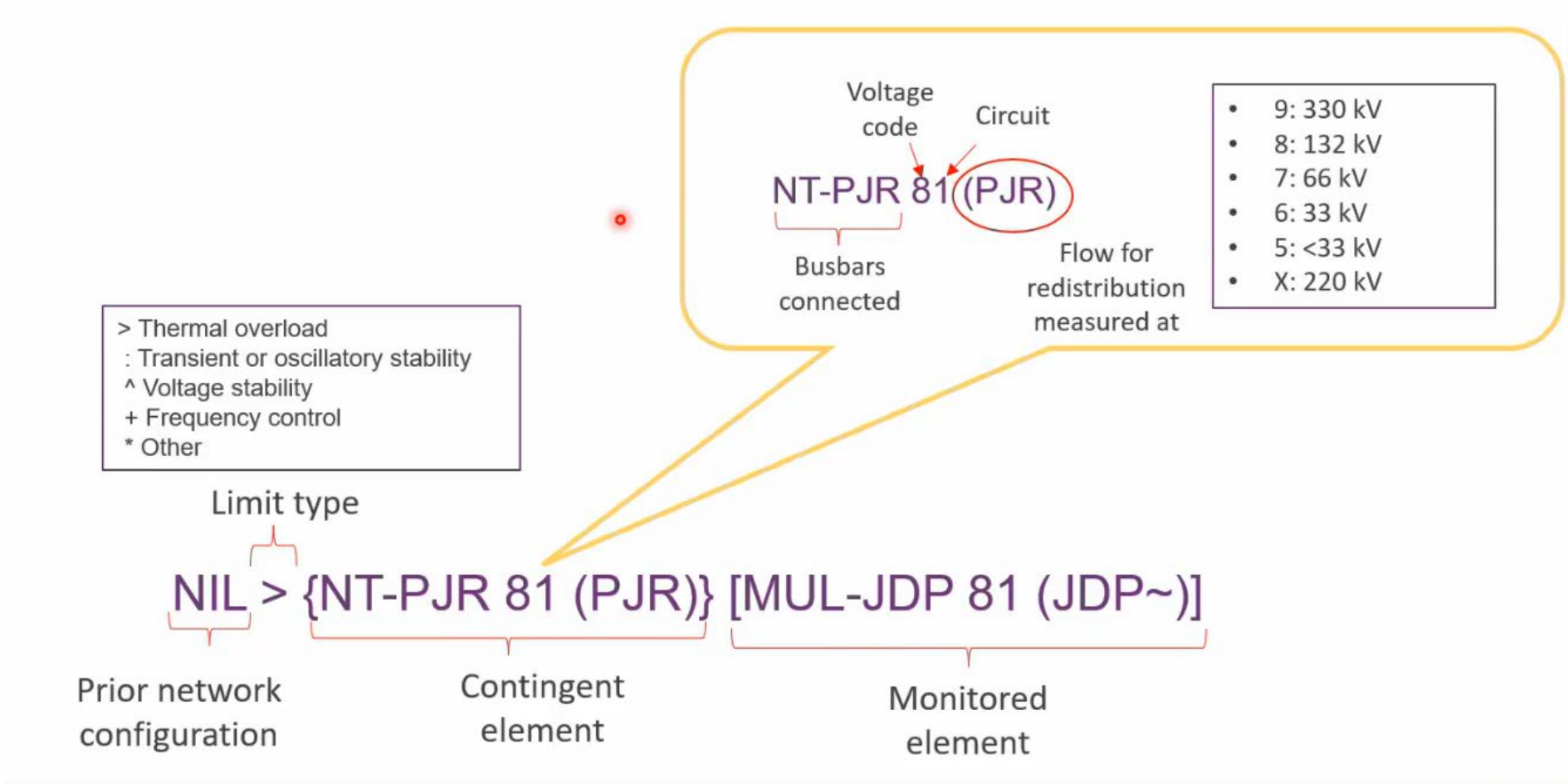
Network Constraints

- Western Power develops the network limits, and these are converted into network constraints by AEMO for use by WEMDE
- Network Constraints are designed to protect certain elements of the network against the next credible contingency
- Additional constraint sets can be invoked when there are network outages, so that the outage can be used in the WEMDE solve

Network Constraints

- Network Constraints
  - Thermal
    - Prevent excess heating
    - Thermal ratings on equipment (summer and winter ratings)
  - Non-thermal
    - Design tolerances for voltages
- Constraints are built into WEMDE through equations with LHS and RHS, where:
  - LHS = Controllable elements (Generator setpoints etc.)
  - RHS = Fixed Components in that interval that cannot be adjusted (e.g. line ratings)
- A constraint is “binding” when LHS=RHS
- If a constraint is “violating” means LHS > RHS and WEMDE was not able to find an optimised solution that met the constraint
- “NIL” is the default/System normal setting for the constraints

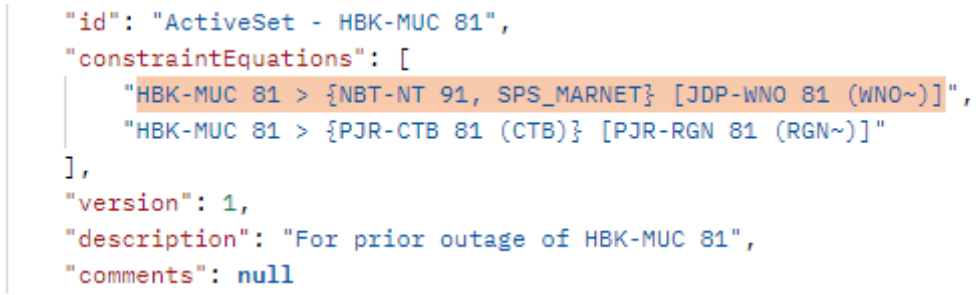
How to read Constraint Equations



Case Study – 25th Nov 2023 17:25 onwards

- Across the heatwave there were several binding network constraints that occurred, mainly thermal constraints
- From 17:25 HBK-MUC 81 > {NBT-NT 91, SPS_MARNET} [JDP-WNO 81 (WNO~)] was binding

  At the time there was a Western Power line outage meaning an additional set of constraints were invoked



- NEWGEN_NEERABUP_GT1 was constrained as this was the most optimised outcome for the market and the constraint
- Market overview at the time - (17:25-18:35) in some intervals there were Contingency Raise shortfalls and Energy hit the price ceiling ($738/MW)

Where to find if a constraint is binding


```
{
    "id": "GenericConstraint_HBK-MUC 81 > {NBT-NT 91, SPS_MARNET} [JDP-WNO 81 (WNO~)]",
    "description": "GenericConstraint HBK-MUC 81 > {NBT-NT 91, SPS_MARNET} [JDP-WNO 81 (WNO~)]",
    "leftHandSideValue": 359.527,
    "operator": "LessThanOrEqualTo",
    "constraintType": "Network",
    "rightHandSideValue": 359.527,
    "defaultRhs": 317.6,
    "bindingConstraintFlag": true,
    "nearBindingConstraintFlag": true,
    "shadowPrice": -8190.13,
    "isInterventionEvent": false,
    "slackVariables": [
        {
            "variable": "HBK-MUC 81 > {NBT-NT 91, SPS_MARNET} [JDP-WNO 81 (WNO~)]_SlackSurplus",
            "value": 0.0
        }
    ]
},
```


In the Solution File:

If the “bindingConstraintFlag is ‘true’ for the constraint then it is binding in that interval

```
"id": "HBK-MUC 81 > {NBT-NT 91, SPS_MARNET} [JDP-WNO 81 (WNO~)]",
"description": "Prior network configuration: HBK-MUC 81. Prevent thermal overload of JDP-WNO 81 (measured at WNO, positive flow direction) on trip of NBT-NT 91, SPS_MARNET (NBT-NT 91 measured at NBT, NBT-YDT 91 measured at NBT, ENT-YDT 91 measured at YDT, WDW-ENT 91 meas",
"comments": "Update message: use minutesSincePrimary so closed-loop eqn only used in primary dispatch interval\n=====\nCreated: 2023-10-05T09-24-40\nScript: build_xlsx.py\nCommit: 4f0c8cd5fcce2aca3dec2389bcec0d9ce0aaa260\nArchive: bee1c9b8-025e-4e70-a36d-9196365c9b68 (2023",
"leftHandSide": [
    {
        "term": "NEWGEN_NEERABUP_GT1.energy.setpoint",
        "coefficient": 0.6668,
        "termType": "SOLVER",
        "index": 0
    },
    {
        "term": "NEWGEN_NEERABUP_GT1.regulationRaise.setpoint",
        "coefficient": 0.6668,
        "termType": "SOLVER",
        "index": 0
    },
    {
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    {
        "term": "BADGINGARRA_WF1.energy.setpoint",
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    {
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    },
    {
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    },
    {
        "term": "MUNGARRA_GT1.energy.setpoint",
        "coefficient": 0.5148,
        "termType": "SOLVER",
        ....
```

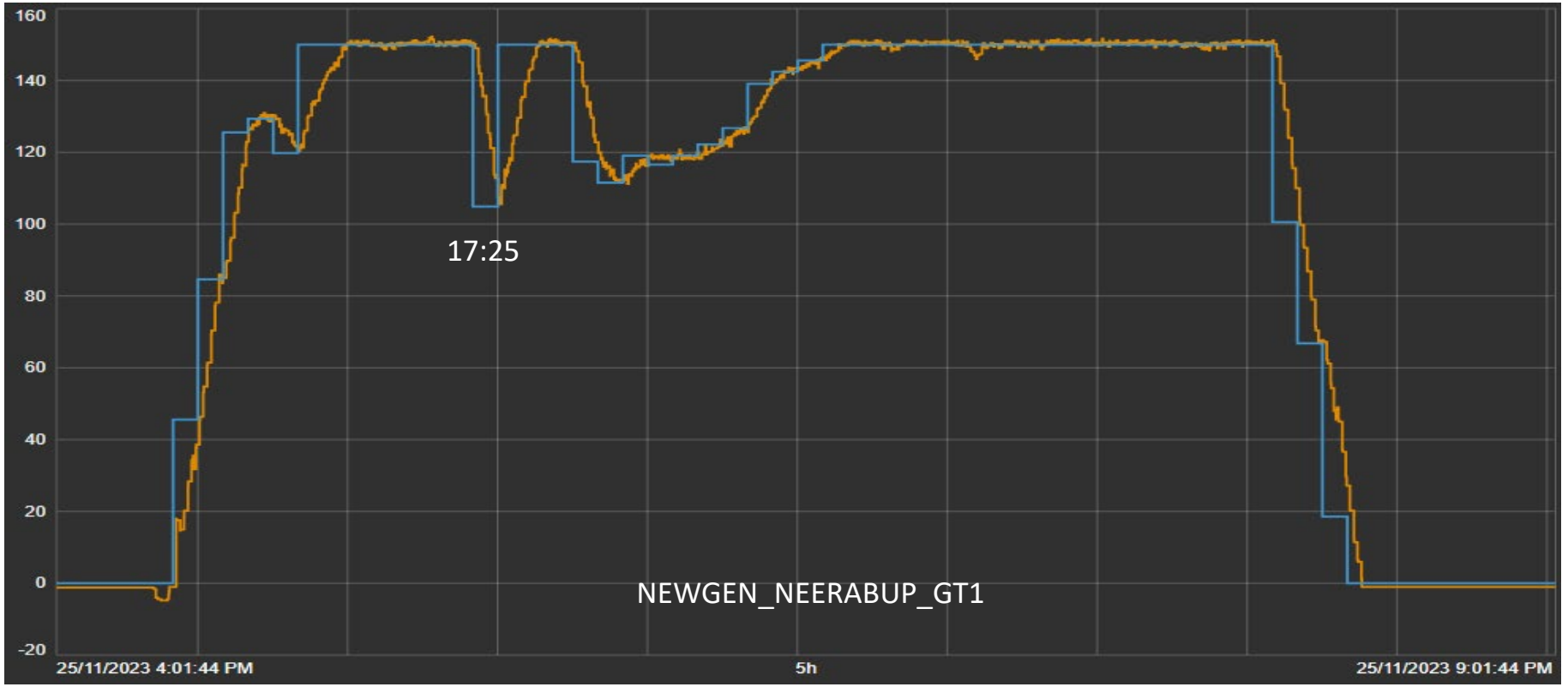

Note: Energy and Raise services (both Regulation and Contingency) are included in this equation

+ve coefficients mean that facility would be increasing the flow on the line
- ve coefficients mean decreasing the flow on the line
Higher coefficient value means higher impact on the line

Search the Constraint name in the Case File for a description of the Constraint and the facilities that contribute and their coefficient
(Note: this snapshot does not include all facilities part of this constraint)

Outcome on Generators

- NEWGEN_NEERABUP_GT1 has the highest coefficient within that constraint meaning it has the greatest impact on the line
- When the constraint was binding, WEMDE found the most optimised solution was to constrain the output of NEWGEN_NEERABUP_GT1 to reduce the flow on the line and reduce the thermal risk



- This was resolved by 18:40 when dispatch rose back to ~150MW

Summary

- Network Constraints are built into equations WEMDE can use in its solve to dispatch within network limits
- Casefile shows description of the constraints
- Solution file shows which constraints are binding
- During the heatwave there were instances of thermal constraints binding causing contributing facilities to be constrained by WEMDE to reduce the risk on that line where this was the most co-optimised solution

PINJAR Unit Constraints

Presenter	Adrian Pearce
Purpose	To explain why various PINJAR units have been constrained on by AEMO Control Room over the 10th and 11th December.

PINJAR units constraining – 10th & 11th Dec

Events

1. AEMO's Real-Time Frequency Stability (RTFS) tool indicated the Power System was insecure, despite WEMDE indicating no shortfalls.
   - The RTFS tool monitors system stability using a different calculation to WEMDE.
2. AEMO Control Room required further Contingency Raise (CR) to make the system secure so it invoked discretionary constraints to bring on PINJAR units.
3. Bringing on the PINJAR units increases the amount of CR available but also increases the largest allowable Contingency size (as calculated by WEMDE).
4. This results in the RTFS tool indicating the system is still in-secure and we return to Step 1.

Actions:

An imminent update tuning the Dynamic Frequency Control Model (DFCM) will more closely align WEMDE and the RTFS.

- The DFCM is an offline model of power system frequency that determines the secure operating space for WEMDE and informs the market service requirements in dispatch intervals of Contingency Raise and ROCOF.

Capacity Cost Refunds

Presenter	Madison Pigliardo
Purpose	Explain how Not-In-Service and Real-Time Market Offer Shortfall refund quantities are calculated.

Refunds

- Capacity Cost Refunds are calculated per clause 4.26.2E of the WEM Rules.
- This presentation will focus on two types of refund quantities:
  - Not-In-Service Capacity Refunds
  - Real-Time Market Offer Shortfall Refunds
- These both contribute to Facility Reserve Capacity Deficit Refunds

Facility Reserve Capacity Deficit Refunds

- Applies to registered and non-registered **SF**, **SSF**, **NSF** & **DSP** facilities.
- Refund charged when facility does not make their capacity available.

Net STEM Refunds

- **SSF** and **SF**s with CC's.
- Obligated to submit their available capacity into STEM.

DSP Capacity Shortfall Refunds

- **DSP** facilities.
- Obligated to curtail their consumption when they receive dispatch instructions.

Intermittent Load Refunds

- Applies to **IL**s
- Refunds charged when embedded generator associated with IL is not performing at nominated capacity.

Not-In-Service Refunds

- Not in service refund quantities are calculated per *Dispatch Interval* and averaged per *Trading Interval.*

- Facilities can face Not-In-Service Refunds if:
  - They are a *Semi-Scheduled* or *Scheduled Facility;*
  - They have a non-zero *Not-In-Service Capacity Quantity;*
  - There is no *Market Suspension* during the interval;
  - They are not undergoing a *commissioning test* or full *planned outage;* and
  - They do not make available capacity *In Service* when it is expected to be dispatched.

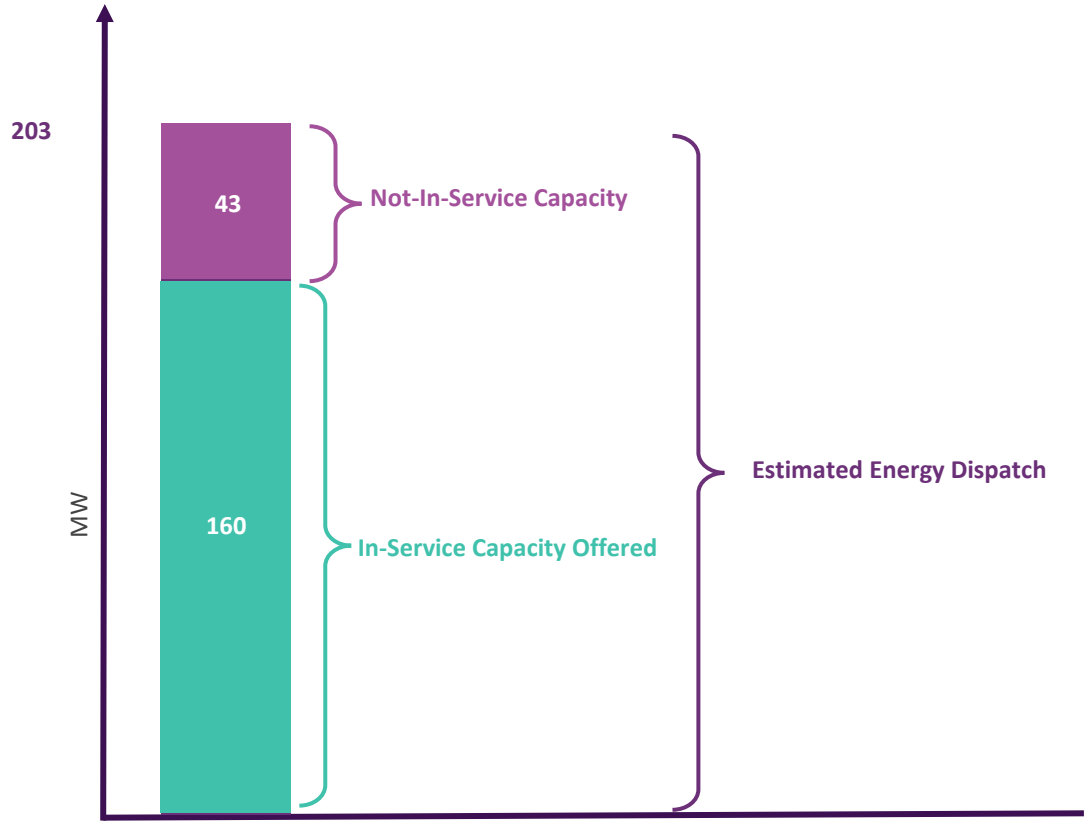
Calculation of Not-In-Service Capacity

- Section 7.13A of the WEM Rules defines the calculation of Not In-Service Capacity.

$$NISCap(f,DI) = Max(0, Min(RCOQ(f,DI), EstDispEnergy(f,DI)) - Max(ISSDCEnergy(f,DI), ISDispEnergy(f,DI))$$

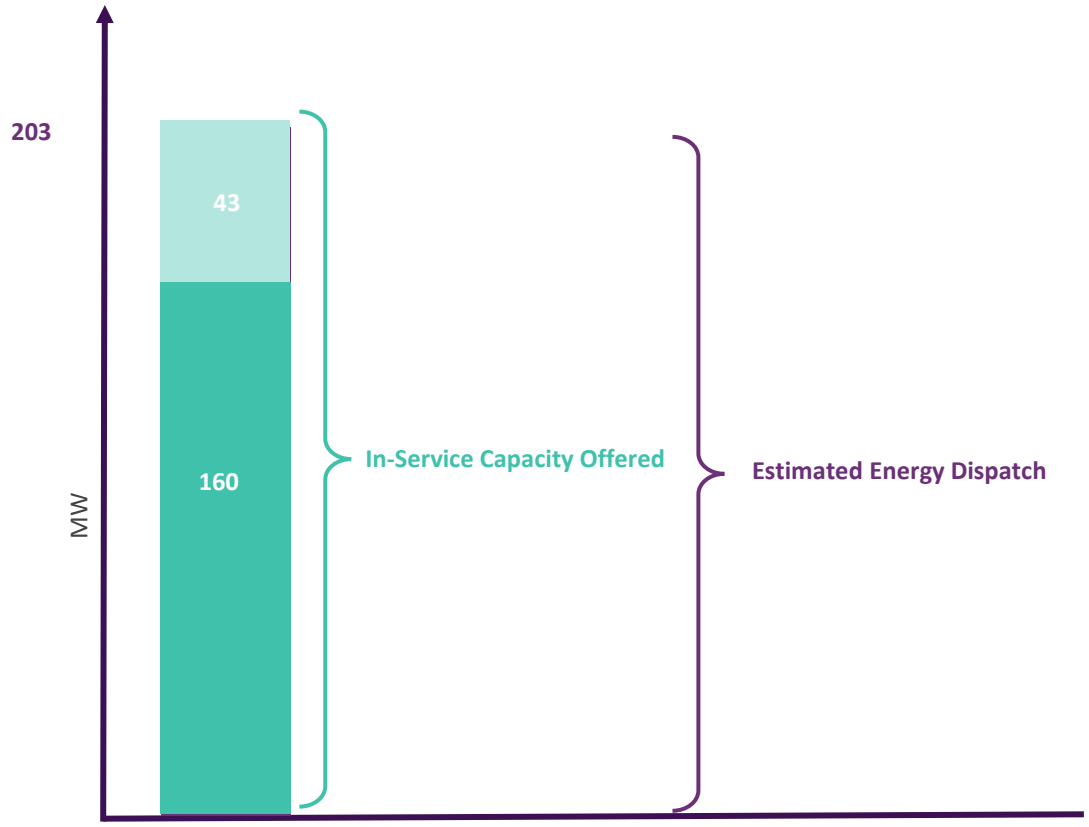
- It is calculated for each Dispatch Interval independently.
- The calculation considers two main points:
  - If a Facility was forecasted to be dispatched in the relevant Dispatch Interval according to the Market Schedule immediately prior to the Start Decision Cutoff Time.
  - Whether the Market Participants made that capacity IN-SERVICE for the relevant Dispatch Interval, even after the Start Decision Cutoff Time.

Not-In-Service Quantity: Notice Period



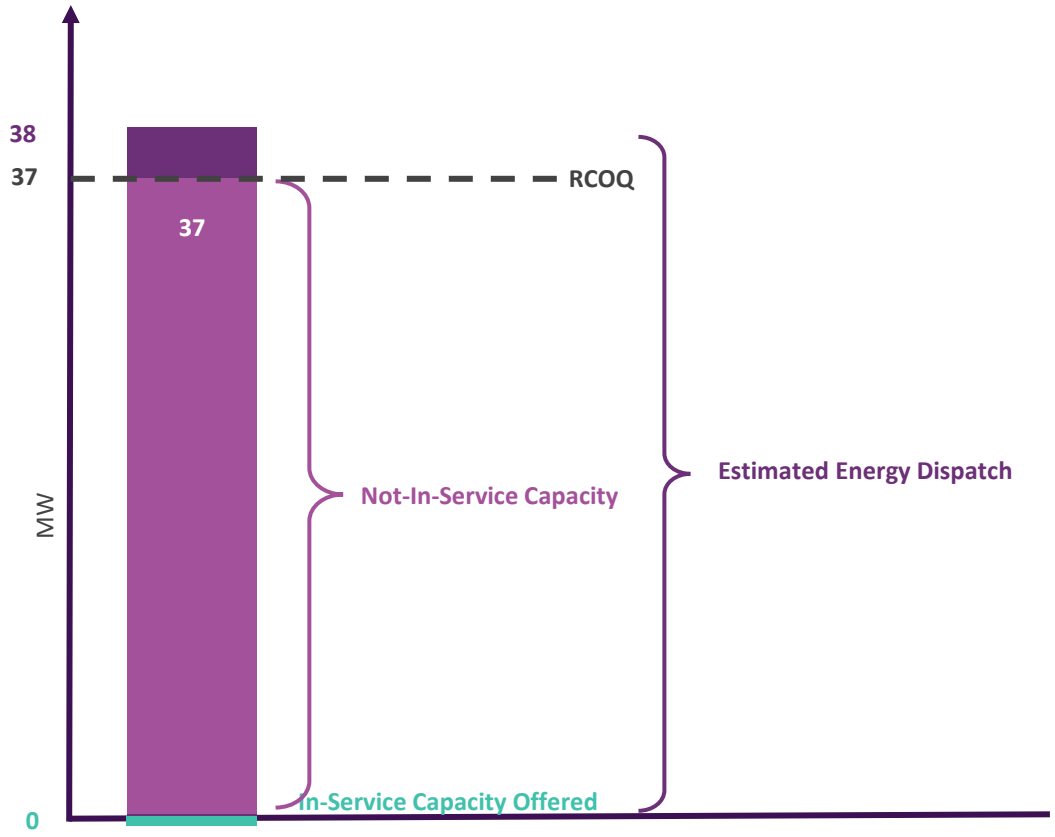
- The Facility has an Estimated Energy Dispatch quantity of 203 MW immediately prior to the Start Decision Cutoff Time (30 minutes):
  - *160 MW from Tranche 1*
  - *43 MW from Tranche 2*
- 160 MW of In-Service capacity was offered immediately after the Start Decision Cutoff Time
- Not-In-Service capacity is 43 MW
  - *Estimated Energy Dispatch – In-Service Capacity offered*

Not-In-Service Quantity: Gate Closure



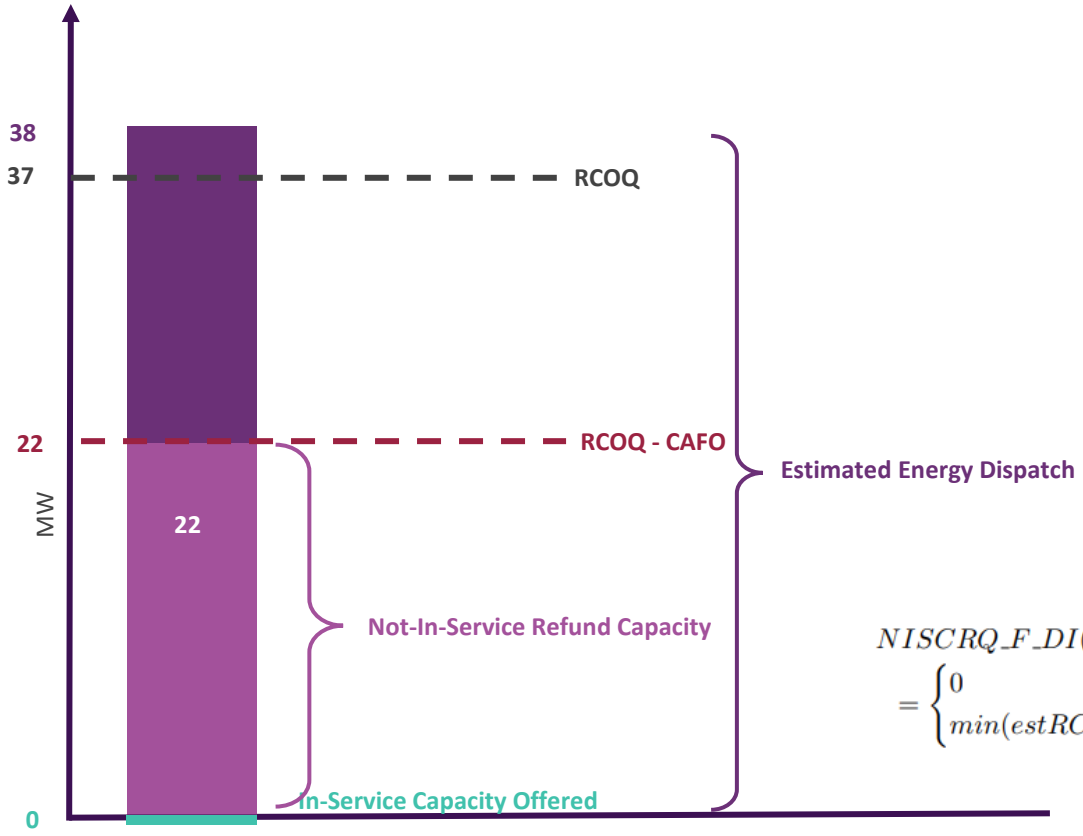
- The Facility has an Estimated Energy Dispatch quantity of 203 MW immediately prior to the Start Decision Cutoff Time (30 mins):
  - *160 MW from Tranche 1*
  - *43 MW from Tranche 2*
- 160 MW of In-Service capacity was offered immediately after the Start Decision Cutoff Time
- Prior to Gate Closure 15 minutes before the Interval, the remaining 43 MW was moved to In-Service
  - *203 MW > 160 MW*
- Not-In-Service capacity is 0 MW
  - *Estimated Energy Dispatch – In-Service Capacity offered*

Not-In-Service Quantity: RCOQ



- NISCRQ is capped at the facility's RCOQ during the Dispatch Interval
  - *37 MW*
- The Facility has an Estimated Energy Dispatch quantity of 38 MW immediately prior to the Start Decision Cutoff Time:
  - *38 MW from Tranche 1*
- 0 MW of In-Service capacity was offered immediately after the Start Decision Cutoff Time
- Not-In-Service capacity is 37 MW
  - *Min(RCOQ, Estimated Energy Dispatch – In-Service Capacity offered)*

Not-In-Service Quantity: Forced Outage



- NISCRQ is capped at a facilities RCOQ during the Dispatch Interval (37 MW)
- The Facility has an Estimated Energy Dispatch quantity of 38 MW immediately prior to the Start Decision Cutoff Time:
  - *38 MW from Tranche 1*
- 0 MW of In-Service capacity was offered
- The facility is subject to a Capacity Adjusted Forced Outage (CAFO)
  - *15 MW*
- Not-In-Service capacity is 22 MW
  - *Min(RCOQ-CAFO, Estimated Energy Dispatch – In-Service Capacity offered)*

$$NISCRQ\_F\_DI(f,di) = \begin{cases} 0 & \text{if } RTMSuspFlag\_G\_DI(di) = 1 \\ min(estRCOQ\_F\_DI(f,di) - CAFO\_F\_DI(f,di), NISCap\_F\_DI(f,di)) & \text{otherwise} \end{cases}$$

Real-Time Market Offer Shortfall Refunds

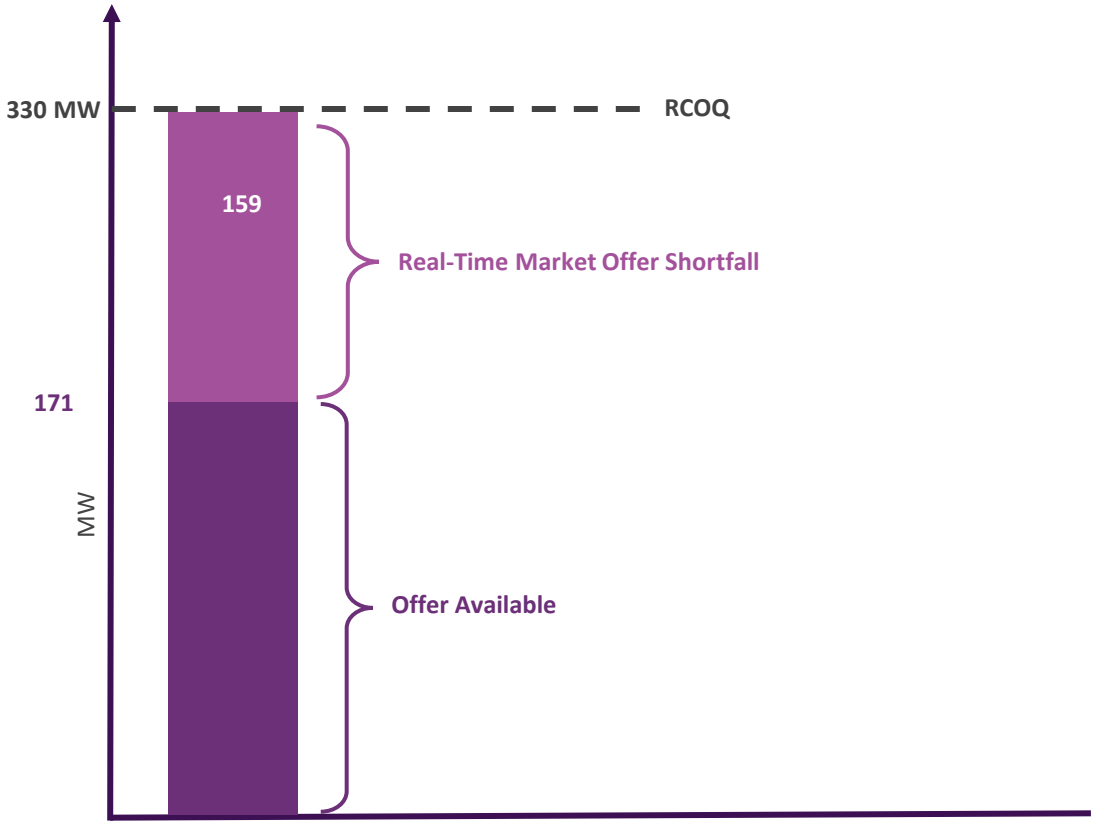
- Real-Time Market Offer Shortfall Refund quantities are calculated for both *Dispatch Interval* and *Trading Interval*

- Facilities can face Real-Time Market Offer Shortfall Refunds if:
  - They are a *Semi-Scheduled* or *Scheduled Facility;*
  - There is no *Market Suspension* during the interval;
  - They are not undergoing a *commissioning test* or full capacity *planned outage;* and
  - They do not offer their available capacity into the *Real-Time Market.*

Offer Available Quantity

- Section 4.26.1H(b) of the WEM Rules defines the calculation of the offer quantity made available.
- It is calculated for each Dispatch Interval independently.
- The calculation sums total MW quantity offered by Gate Closure as:
  - Available Capacity; and
  - In-Service Capacity

Dispatch Interval: Real-Time Market Offer Shortfall



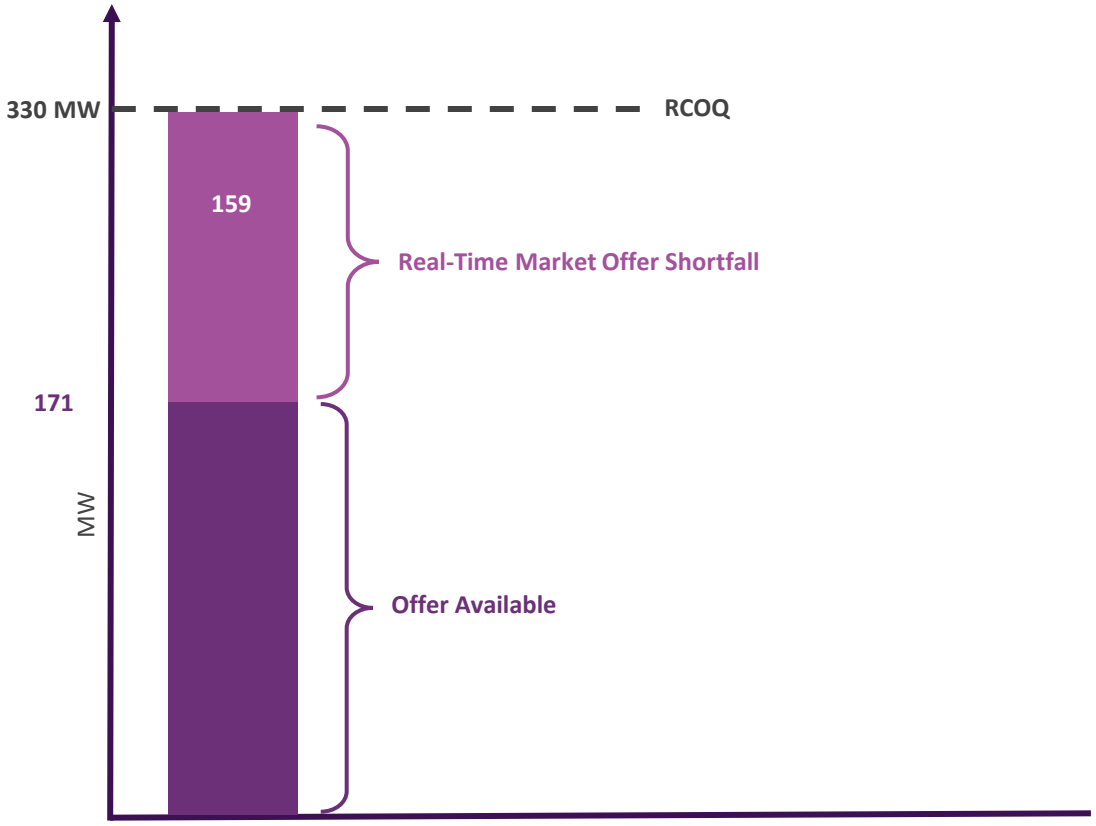
- Offer Available includes both In-Service and Available capacity during the interval:
  - *171 MW Available*
  - *0 MW In-Service*
- RCOQ is 330 MW
- The offer shortfall is calculated as RCOQ minus Offer Available
  - *Shortfall = 330 – 171 = 159 MW*

Real-Time Market Offer Shortfall: Planned Outage

- Offer Available includes both In-Service and Available capacity during the interval:
  - *171 MW Available*
  - *0 MW In-Service*

- The facility was on a planned outage, reducing RCOQ to 171 MW
- The offer shortfall is calculated as RCOQ minus Offer Available
  - *Shortfall = 171 – 171 = 0 MW*

Dispatch Interval: Real-Time Market Offer Shortfall



- Offer Available includes both In-Service and Available capacity during the interval:
  - *171 MW Available*
  - *0 MW In-Service*
- RCOQ is 330 MW
- The offer shortfall is calculated as RCOQ minus Offer Available
  - *Shortfall = 330 – 171 = 159 MW*

Trading Interval: Real-Time Market Offer Shortfall

$$RTMOSF\_F\_I(f,i) = max\left(0, \frac{\sum_{di \in DI(i)} RTMOSF\_F\_DI(f,di)}{6} - CAFO\_F\_I(f,di) - NISCRQ\_F\_I(f,i) - ESRCSF\_F\_I(f,i)\right)$$

- To avoid double-counting the following other refund quantities are subtracted from the Trading Interval level shortfall:
  - *Capacity Adjusted Forced Outage quantity*
  - *Not-In-Service Refund quantity*
  - *ESR Charge Shortfall*

Refunds $ value

- Refund quantities are multiplied by the facility's Trading Interval Refund Rate

$$TIRR\_F\_I(f,i) = RF\_F\_I(f,i) \times Y\_F\_I(f,i)$$

Refund factor for facility for Trading Interval

Reflective of capacity scarcity during an interval

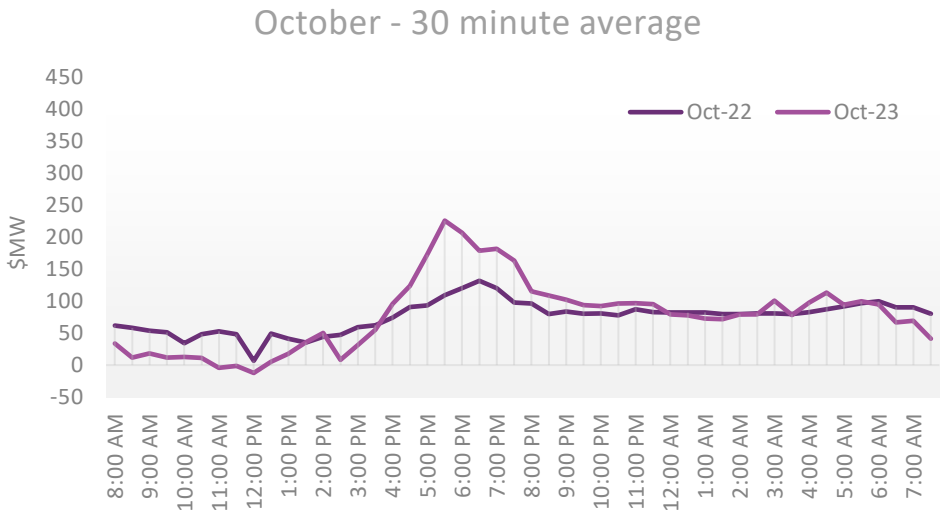
Per interval reserve capacity price for facility

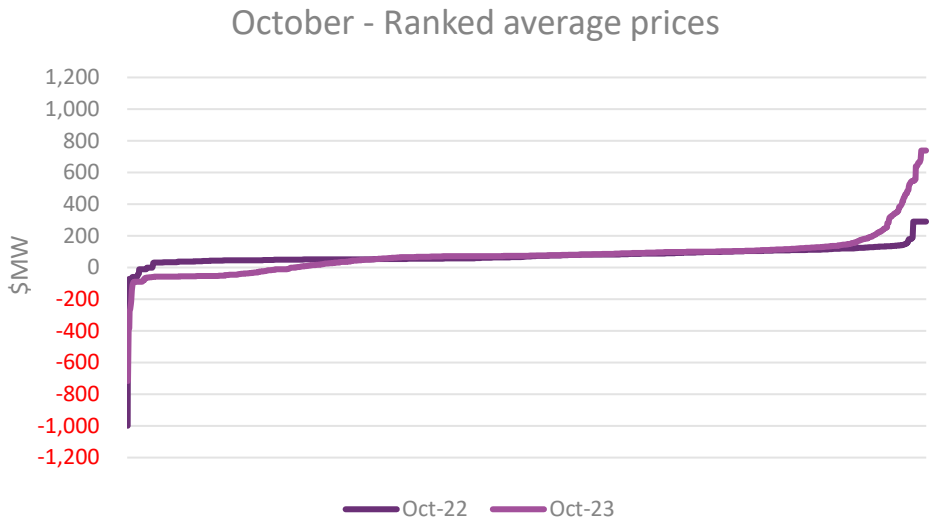
Reflective of value capacity credits paid to facility in an interval

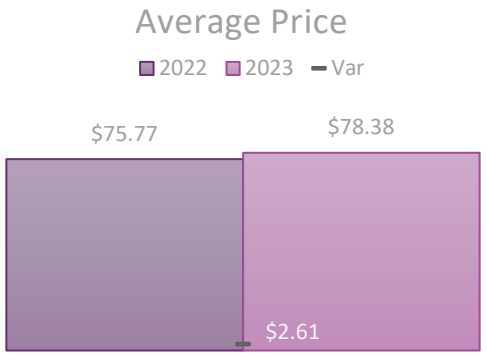
Market Clearing Price Comparisons

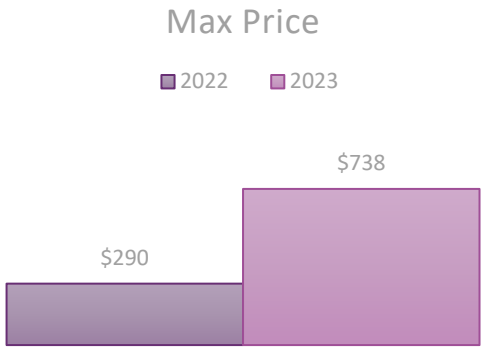
Presenter	Damian Mugridge
Purpose	Statistical analysis of Market Clearing Prices under SCED compared to Balancing.

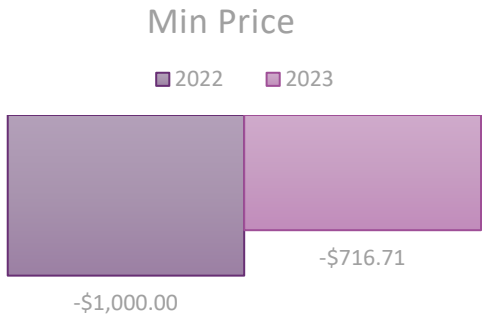
Energy Prices - October



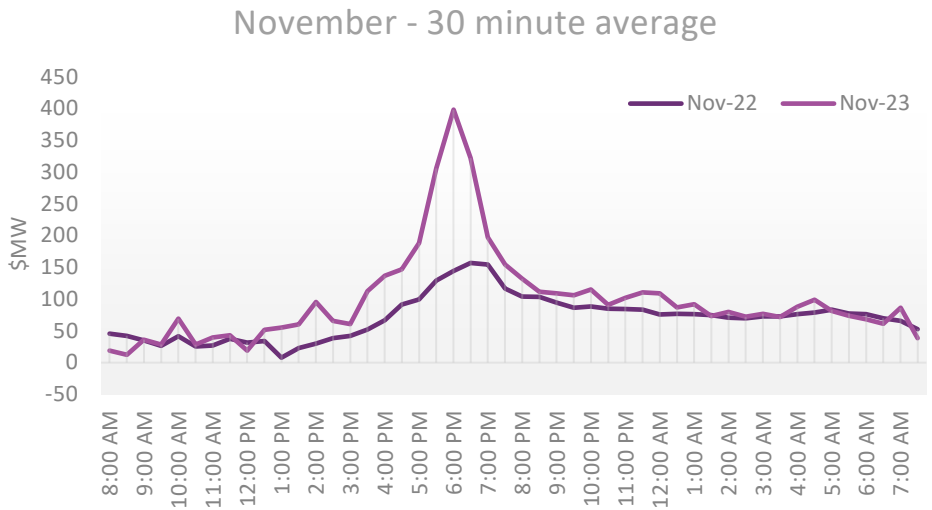


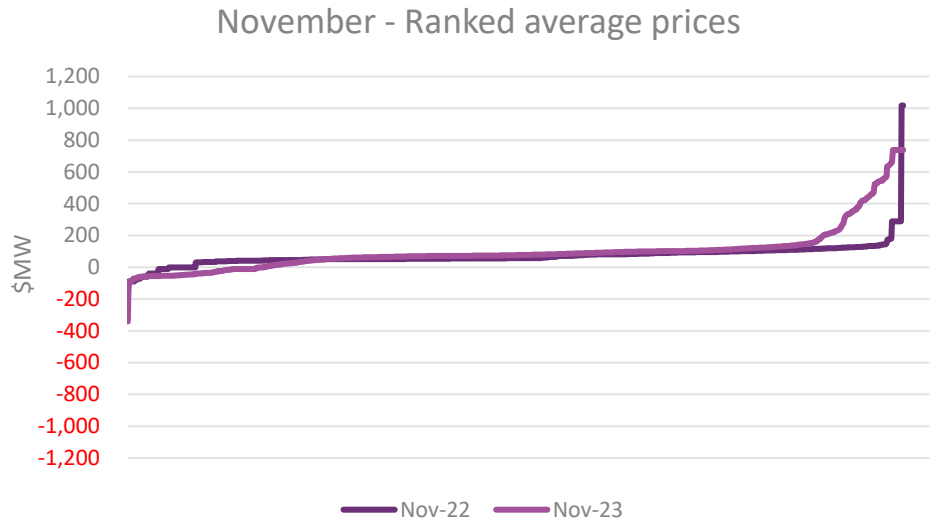


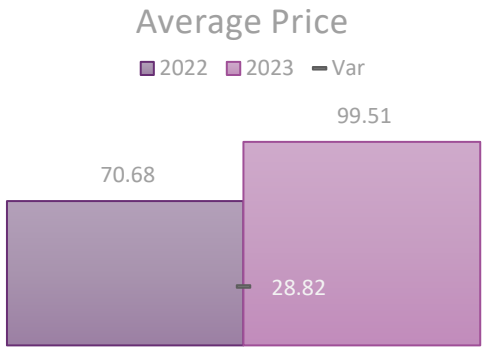


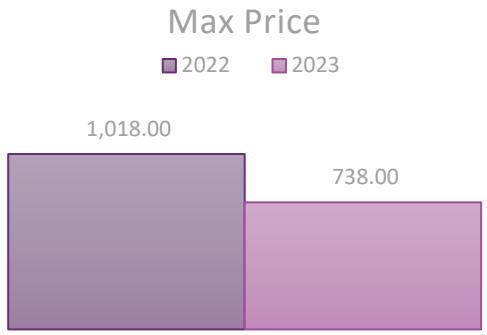


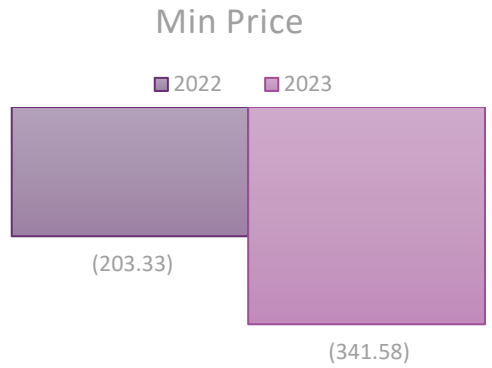
Energy Prices - November



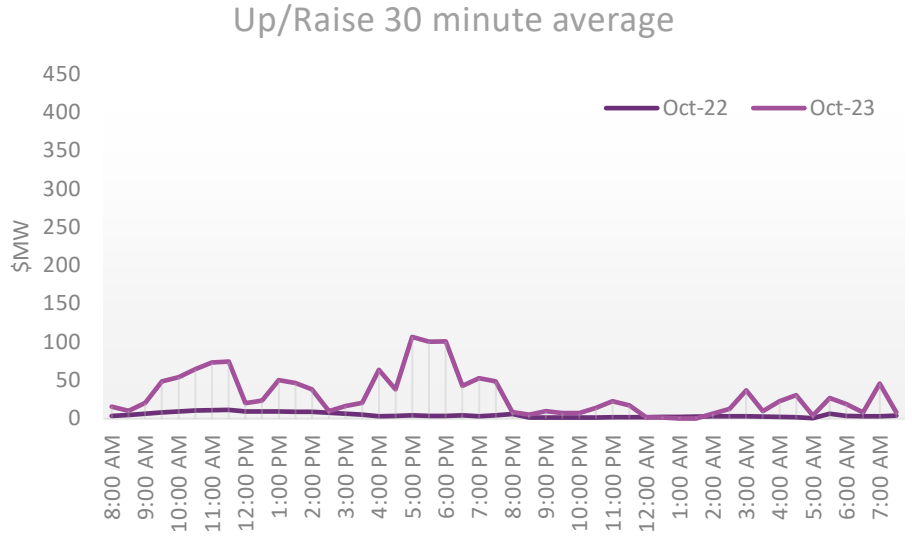


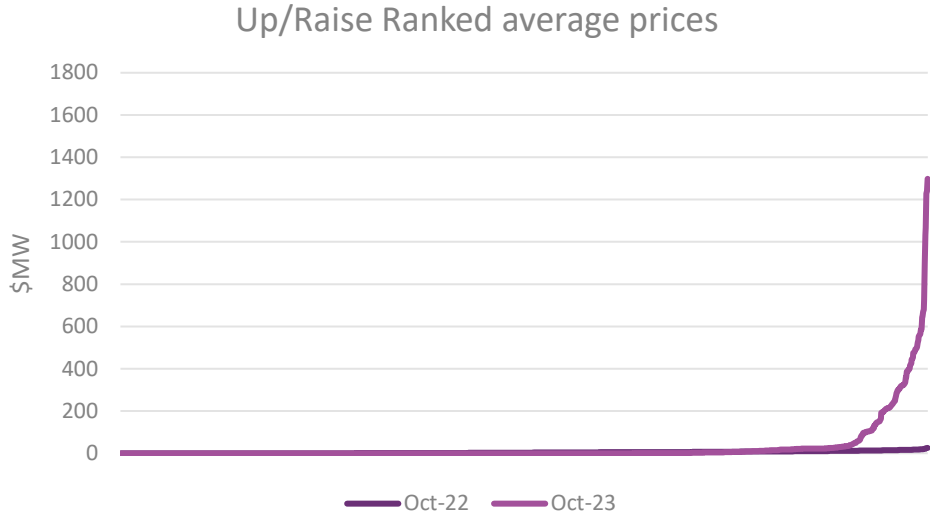


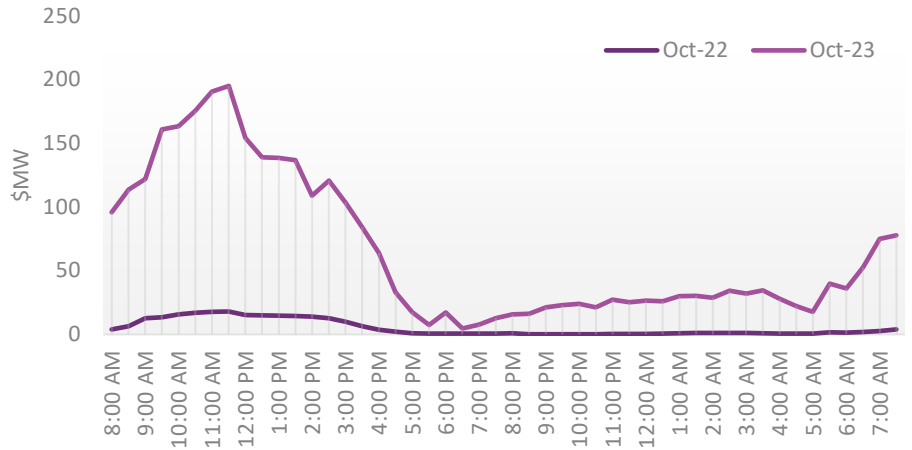


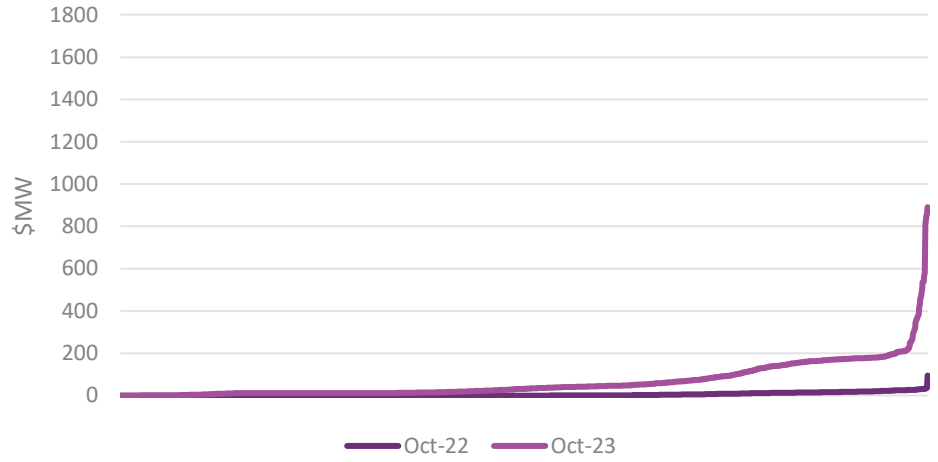


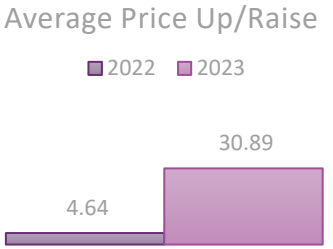
LFAS/Regulation Prices - October

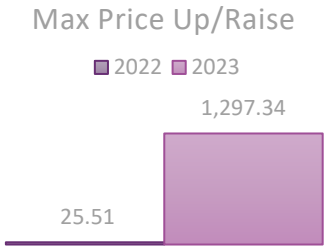


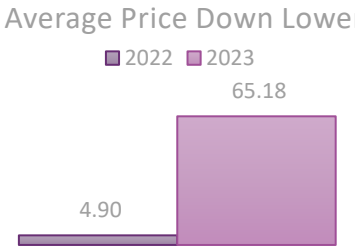


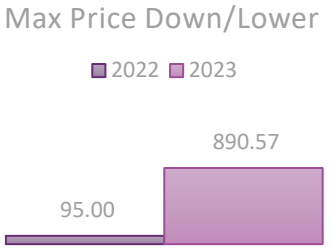




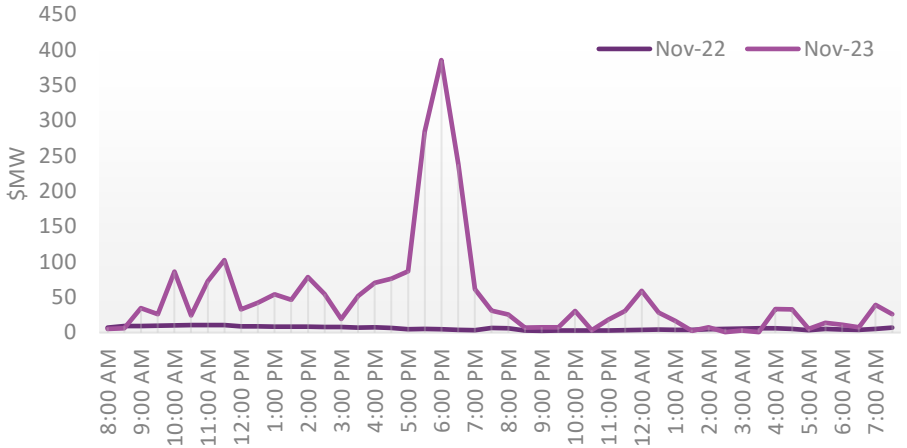


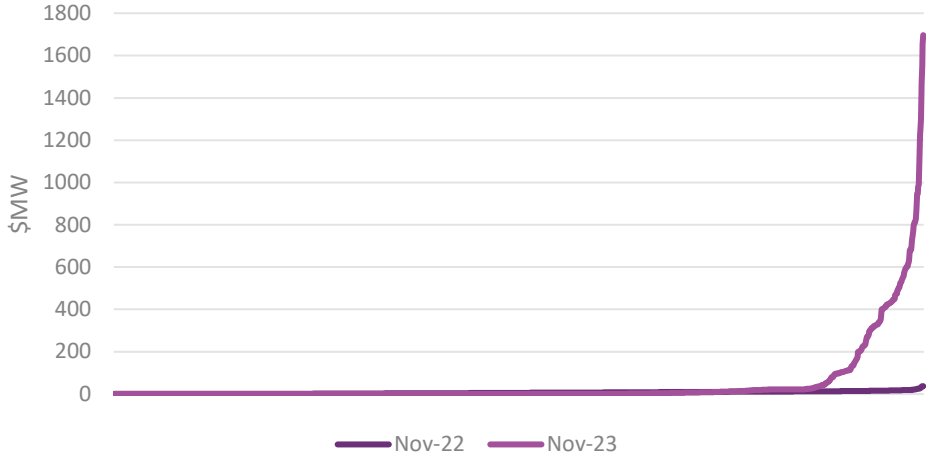


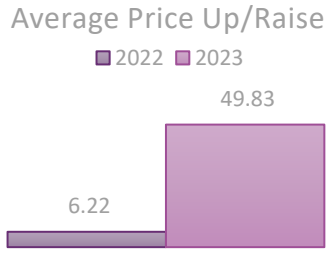


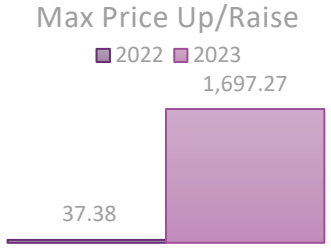


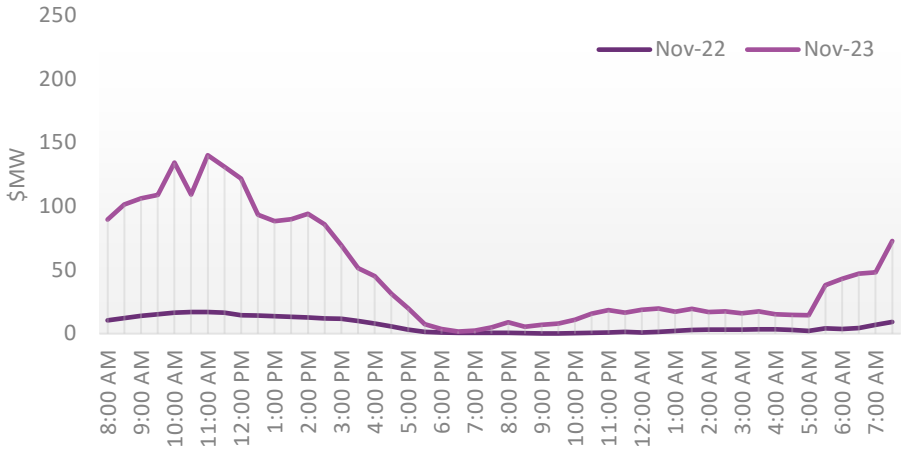
LFAS/Regulation Prices - November

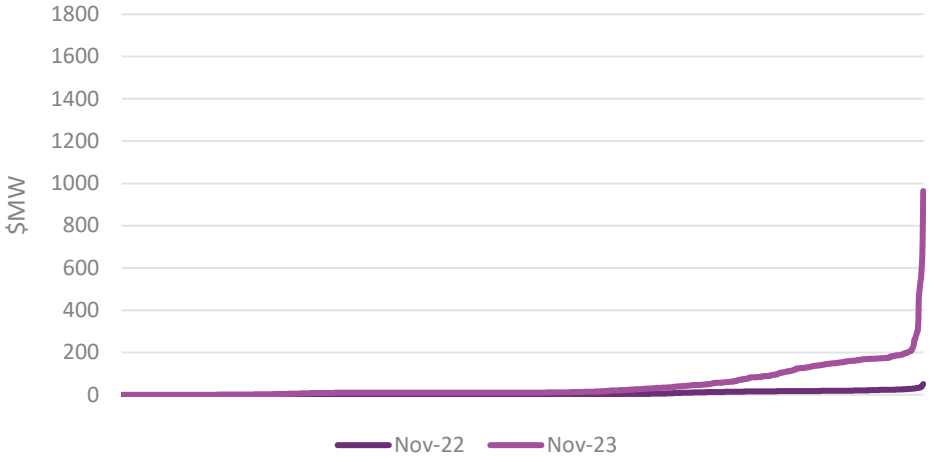


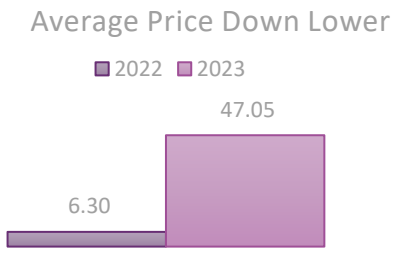


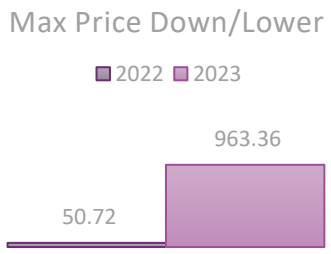












WEMDE Unconstrained Forecast Update

Presenter	Douglas Birse
Purpose	Overview of the changes to WEMDE Unconstrained Forecast Use

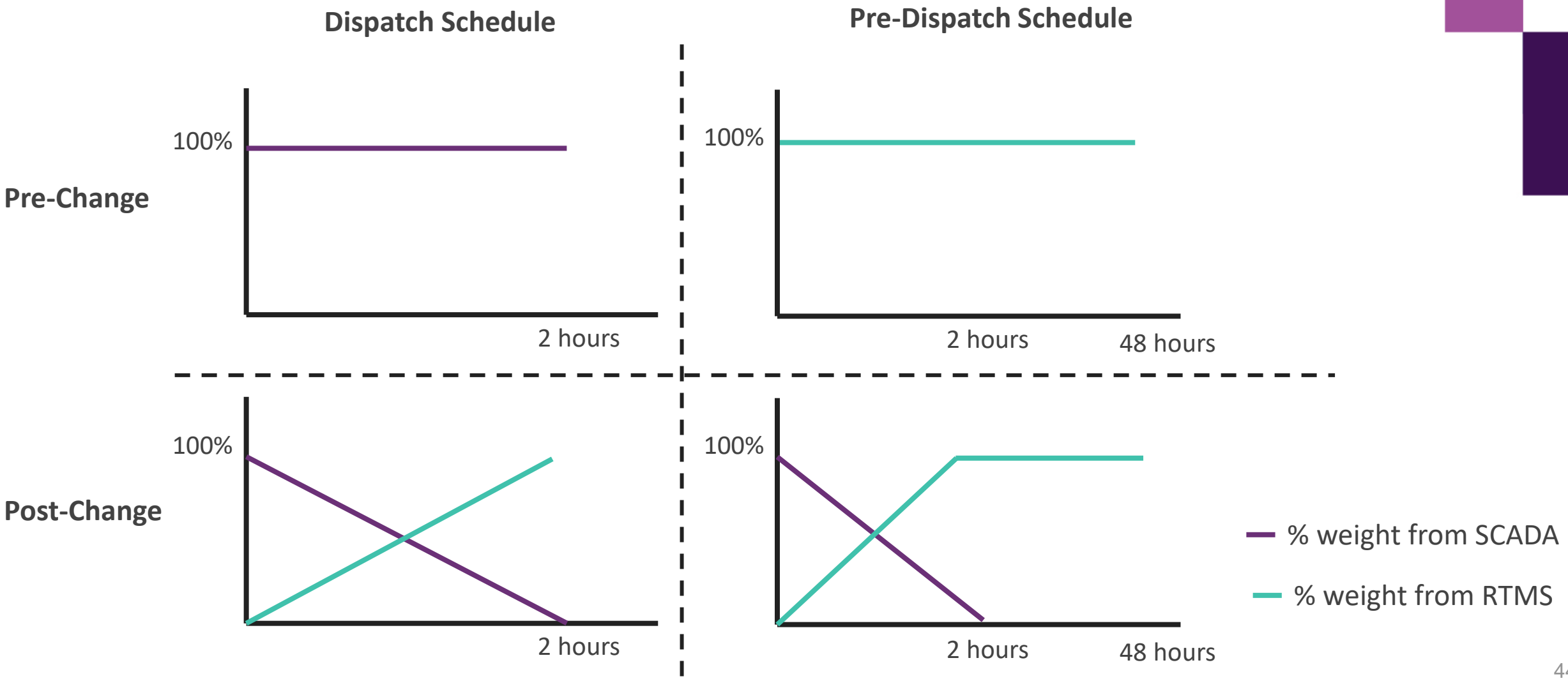
Background

- The WEMDE deployment on 6th December made several changes
  - Majority were not material to Market Participant interactions with a focus on immediate bug fixes
- One change was to implement a “blended forecast” approach for Semi-Scheduled Facilities
  - All Semi-Scheduled Facilities utilise SCADA for their Unconstrained Forecasts which is the Facilities best estimate of its current unconstrained generation
- RTMM are looking for feedback on how Market Participants would like to receive notification of future changes to the Dispatch Engine

Blended Unconstrained Forecast

- AEMO have implemented a blended forecast approach
- This allows a combination of both SCADA and RTMS values to be used to improve forecast accuracy
  - SCADA used is inherently from the Primary Dispatch Interval
  - RTMS is the value taken from the associated Dispatch Interval in the solved schedule
- As of now a linear blending approach has been implemented over a 2-hour period for both the Dispatch and Pre-Dispatch schedules

Impact


Dispatch Schedule
Pre-Dispatch Schedule
Pre-Change
Post-Change
100%
2 hours
48 hours
% weight from SCADA
% weight from RTMS

Questions, Feedback, Ideas

Next RIF scheduled for 13:00 on Tuesday, 23 January 2024

wa.rtm@aemo.com.au

AEMO

AUSTRALIAN ENERGY MARKET OPERATOR

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