Real-Time Market Insights Forum

20 February 2024

Hosted by the WA Real-Time Market Monitoring Team

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

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- The price or other terms at which Participants will supply
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Agenda

#	Item	Speaker
1	Heatwave overview and record average operational demand.	Sophie Burgess
2	Real-Time management of Contingency Raise shortfalls.	Leon Kwek
3	Distributed PV trips and the connection to the Contingency Raise Requirement.	Liam Hayes
4	ESS Pricing and explanation of the ESS Price Ceiling ($2,038)	Douglas Birse
5	System Updates	Various

Investigation:

Heatwave overview and record average operational demand.

Presenter	Sophie Burgess

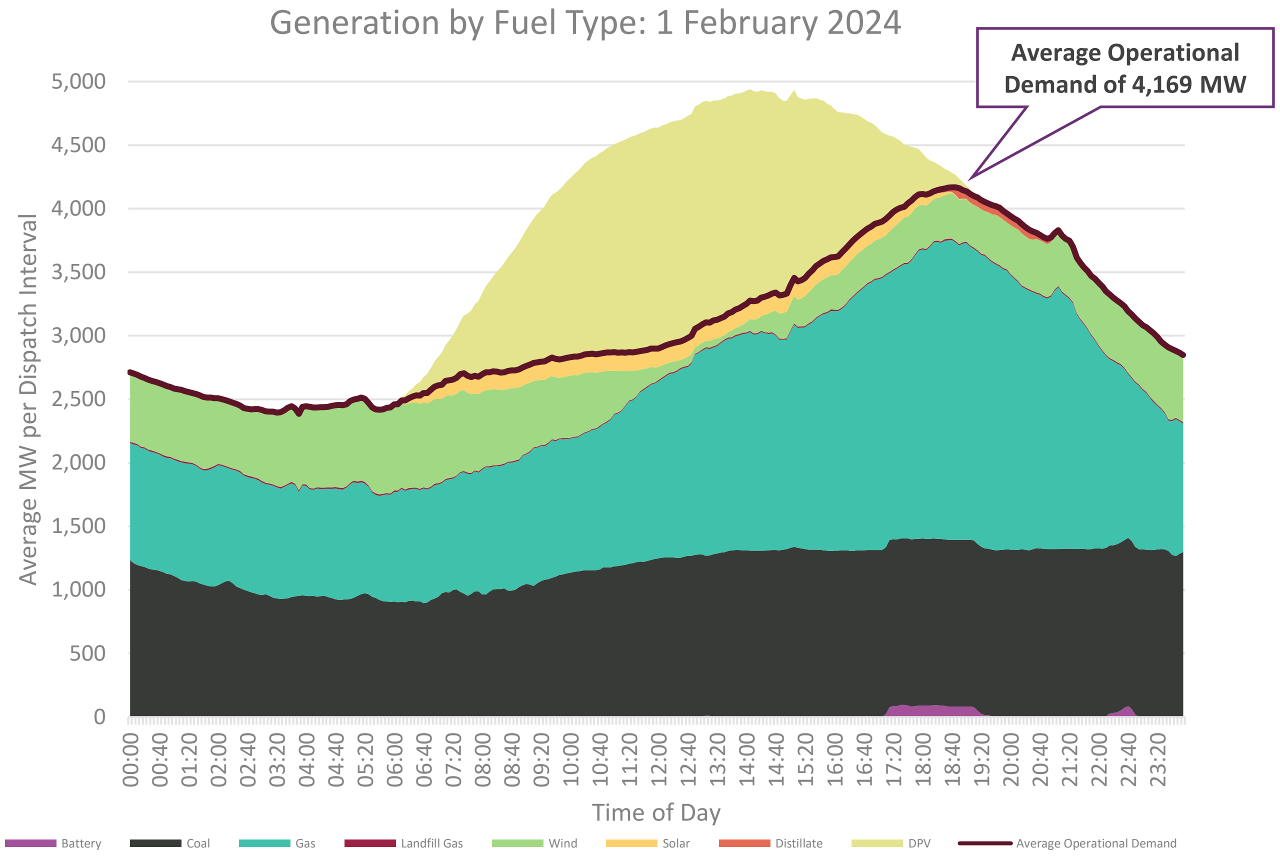
Background 31st-2nd February

- The 31st at 18:40 broke the previous max. average operational demand record with 4,067 MW
- The record was broken again the following day on the 1st February with 4,169 MW during the 18:45 interval
- SRC and DSP Load Reduction were invoked

	31st January Stats	1st February Stats	2nd February Stats
Maximum Temperature	41.9°C	42.6°C	40.4°C
Maximum SWIS Demand	4067MW (@18:40)	4169MW (@18:45)	3760MW (@18:25)
Minimum Temperature	19.2°C	21.7°C	20.5°C
Minimum Operational Demand	2254MW (@08:30)	2336MW (@04:40)	2036MW (@07:45)
Maximum Renewable Penetration	55.71% (@09:40)	48.83% (@10:10)	44.31% (@13:55)

Record Operational Demand

Over 31 January – 1 February the WEM experienced consecutive maximum operational demand records of 4,067 MW and 4,169 MW respectively.



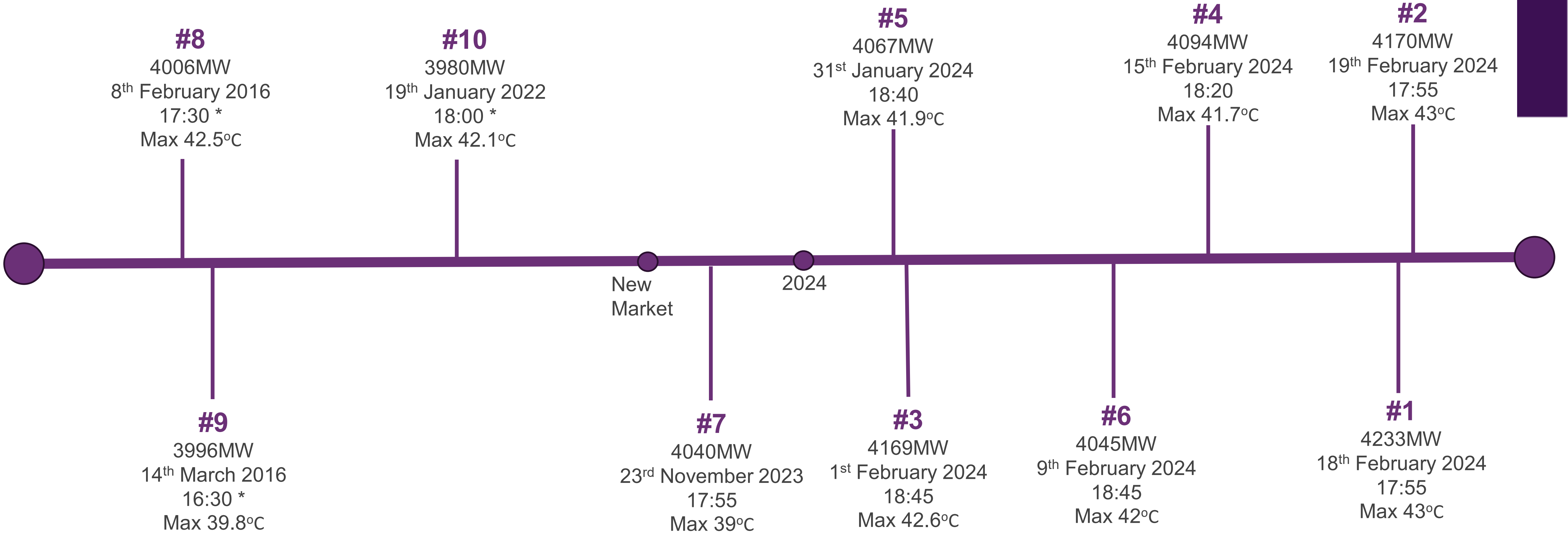
- This outcome was driven by extended heatwave conditions, with temperatures exceeding 40 degrees for a number of days over this period, and a maximum of 42.6 degrees on 1 February. Overnight minimums did not drop below 20 degrees.
- AEMO was required to issue LOR2 declarations for the peak period on both days due to the high demand and low wind conditions; low wind output is common during hot days and is a key operational challenge AEMO need to manage.
- The new record of 4,169 MW was set during the 18:45 Dispatch Interval, which occurs just as DPV output starts reducing as the sun sets.
- Diesel generation was required to be dispatch to manage the peak demand period, as well as DSP and SRC capacity.

Background 18-19th February

- The new record set on the 1st February was short lived, and was broken on 18th February
- It was 39.6°C at 6pm, and still 35+°C at 10pm
- Approximately ~235 MW of SRC and DSP Demand Reduction was invoked on the 18th (similar to other LOR days)

	18th February Stats LOR2	**19th February Stats LOR2**
Maximum Temperature	42.9°C	42.3°C
Maximum SWIS Demand	4233MW (@17:55)	4170MW (@17:55)
Minimum Temperature	23.4°C	27.5°C
Minimum Operational Demand	2024MW (@08:55)	2514MW (@05:00)
Maximum Renewable Penetration	53.3% (@09:40)	46.97% (@09:50)

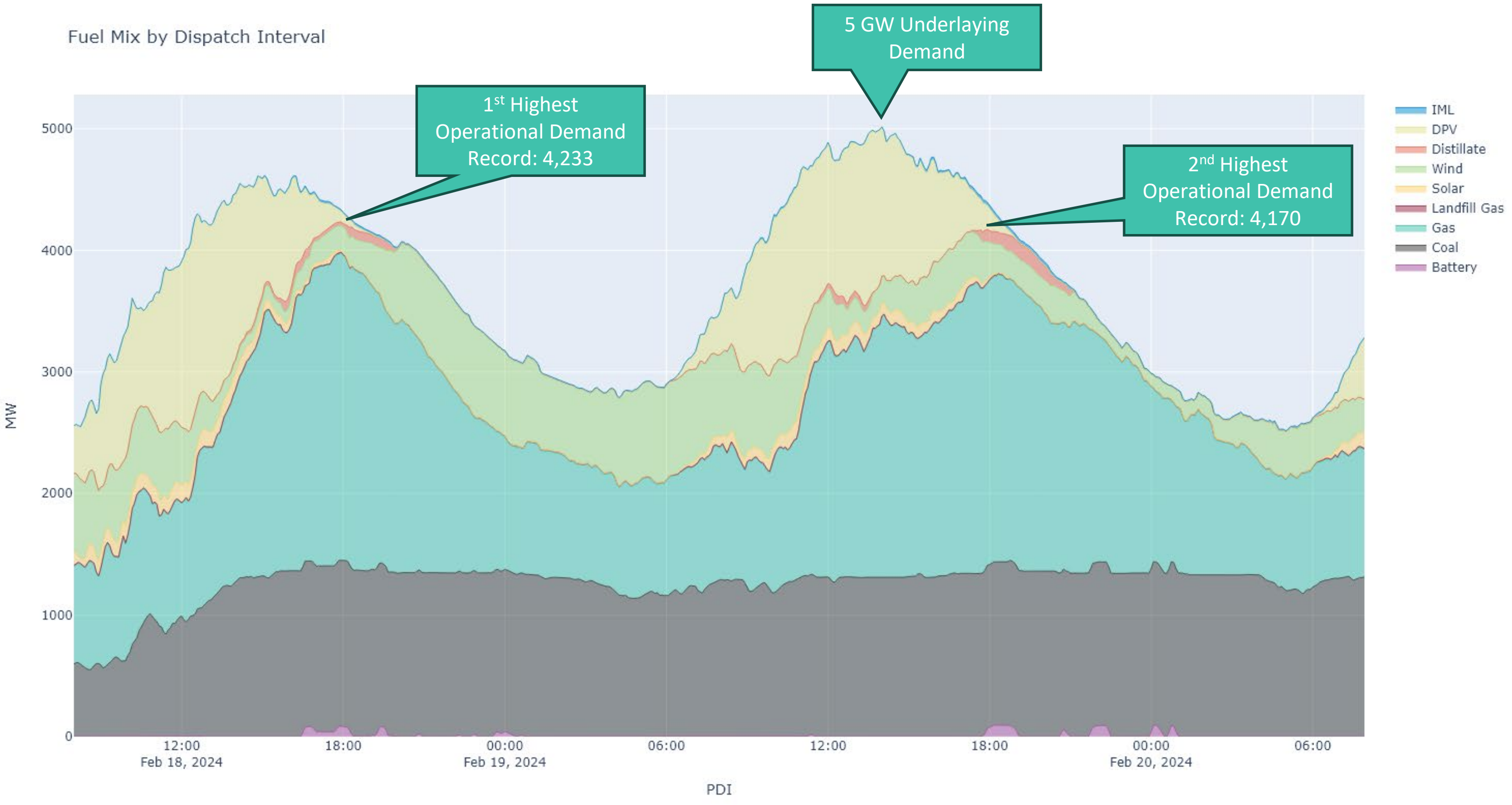
Top 10 Highest Demand Days since the commencement of the WEM



* Pre-New Market Start the Energy market was operated on a 30minute basis

Record Operational Demand

Over 18 - 19 February the WEM experienced consecutive maximum operational demand records of 4,233 MW and 4,170 MW respectively.

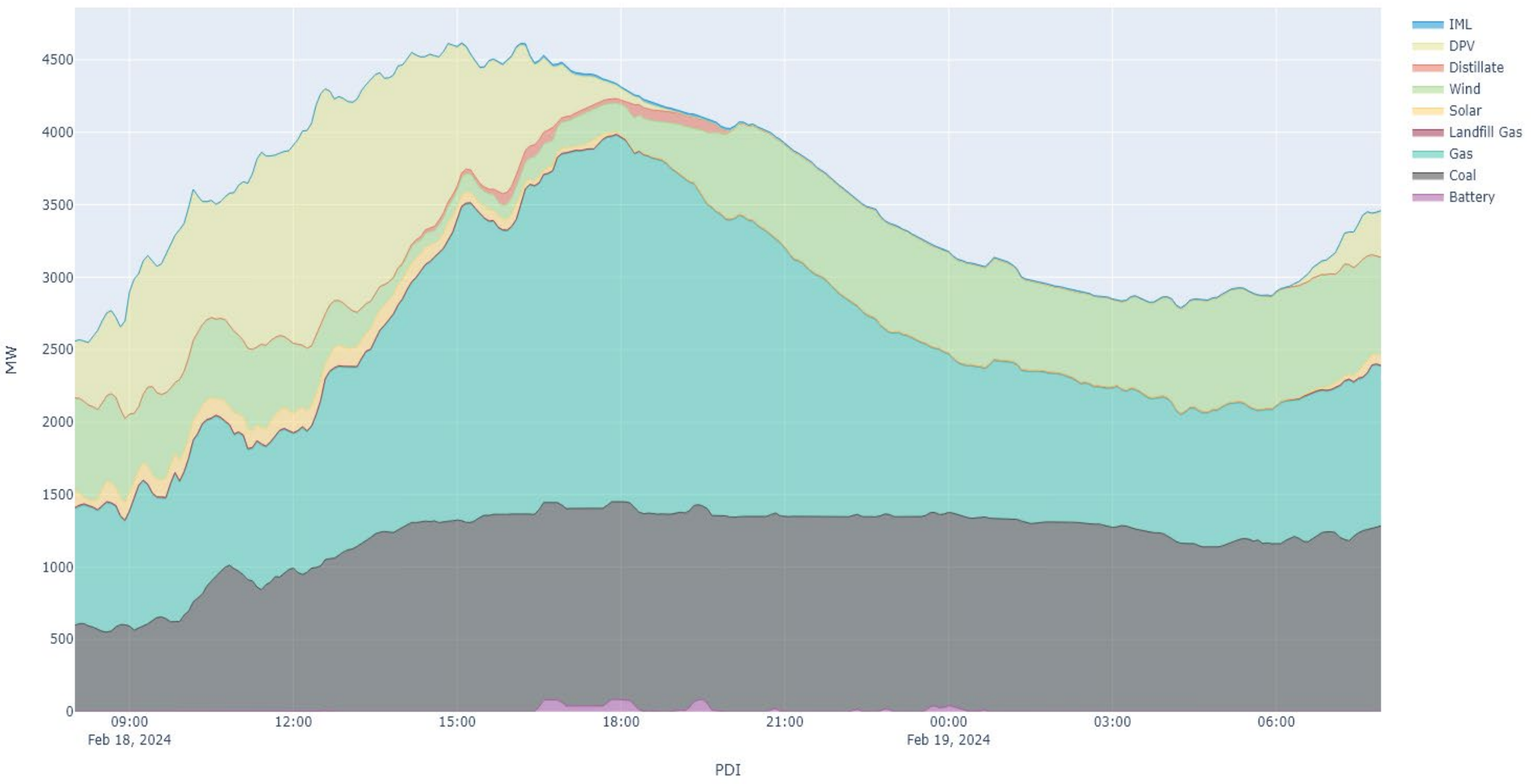


Metric	Quantity	PDI
Min Average Operational Demand	2024.33MW	2024-02-18 08:55
Max Average Operational Demand	4232.94MW	2024-02-18 17:55
Min Underlying Demand	2515.57MW	2024-02-20 05:00
Max Underlying Demand	5016.46MW	2024-02-19 14:00
Min Renewable Penetration	3.47%	2024-02-19 23:50
Max Renewable Penetration	53.3%	2024-02-18 09:40
Avg Renewable Penetration	23.64%	

- Driven by extended heatwave conditions, with temperatures exceeding 40 degrees for a number of days over this period. Overnight minimums did not drop below 27 degrees on 18th/19th.
- AEMO was required to issue LOR2 declarations for the peak period on 18th and issued a forecast LOR3 declaration (i.e. manual load shedding may be required) on the 19th due to high demand and low wind.
- The new record of 4,233 MW was set during the 17:55 Dispatch Interval, which occurs just as DPV output starts reducing as the sun sets.
- Diesel generation was required to be dispatch to manage the peak demand period.
- DSP, SRC and other provisions were activated on both days, delivering an ~235 MW reduction.

Fuel Mix Chart

Fuel Mix by Dispatch Interval

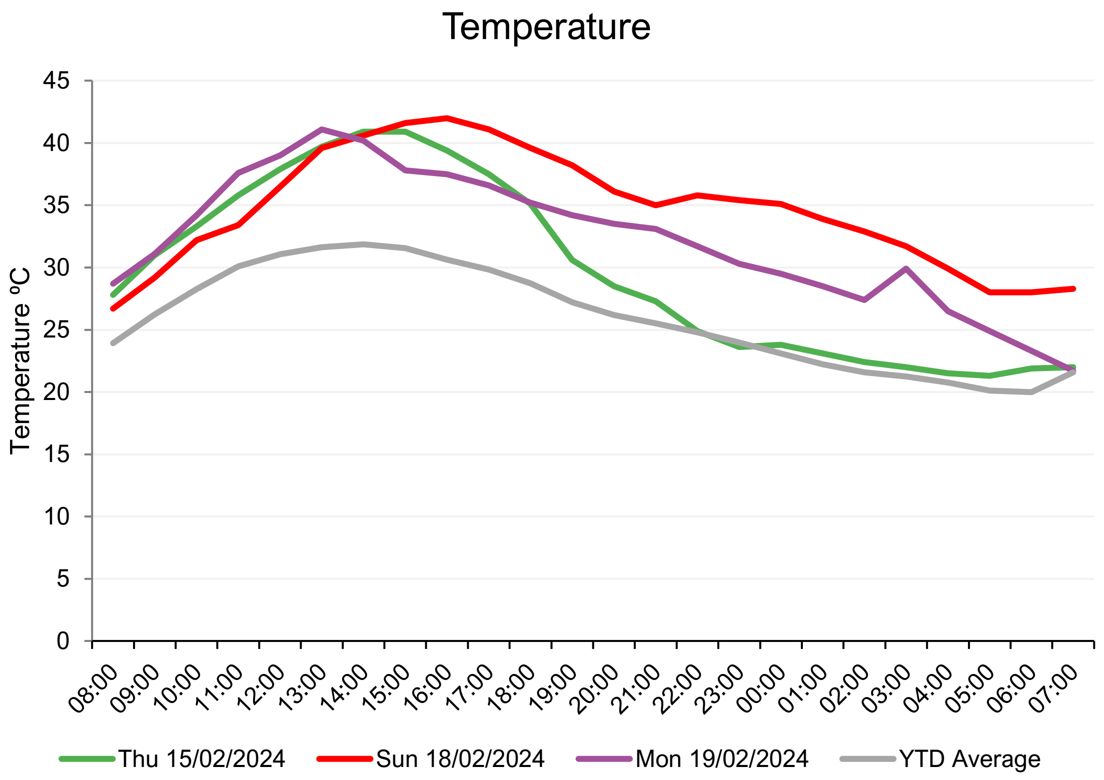


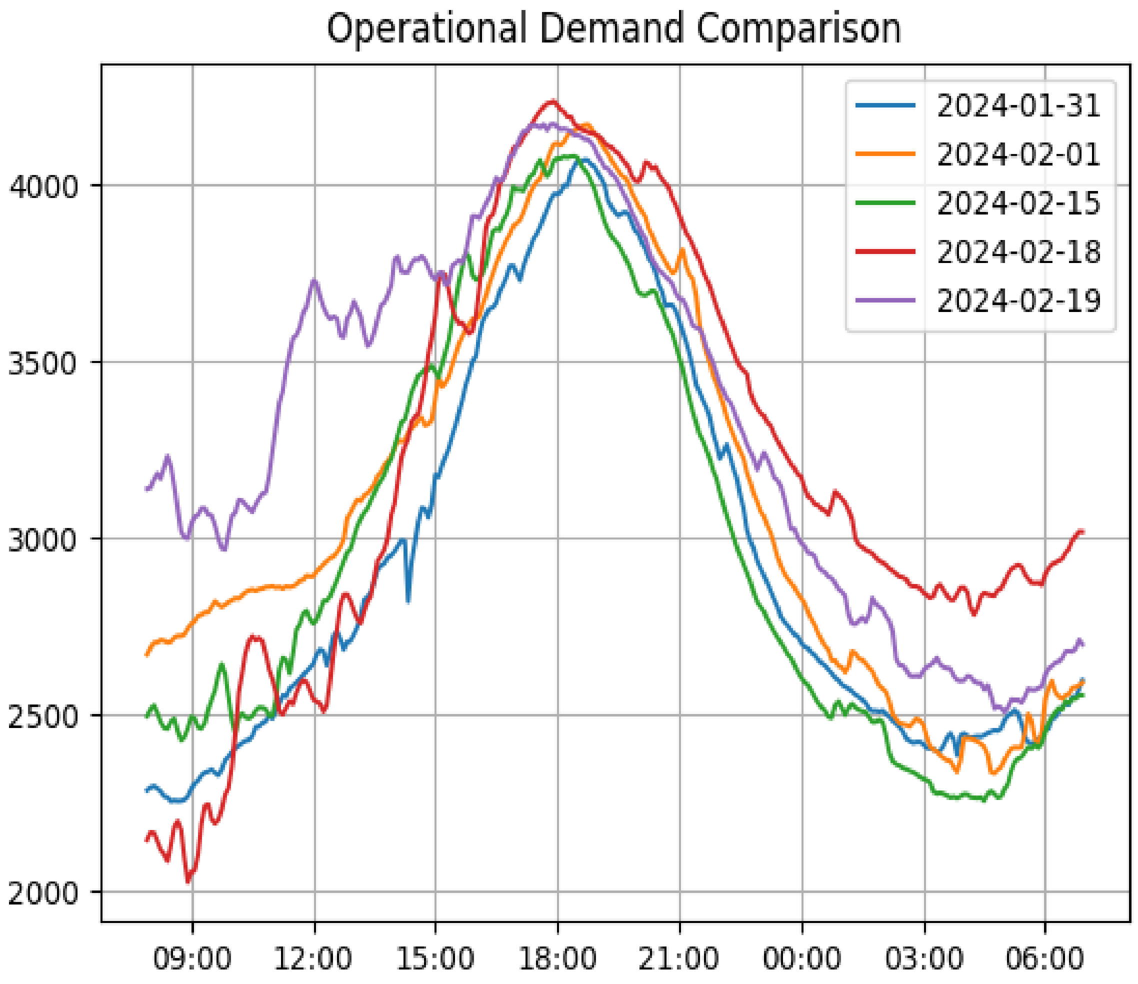
Peak interval (17:55) Fuel Mix

Fuel Type	MW	Fuel Mix OD %	Fuel Mix UD %
Battery	85.7	2.0%	2.0%
Coal	1,364.1	32.1%	31.5%
DPV	90.4	[1]	2.1%
Distillate	30.8	0.7%	0.7%
Gas	2,528.9	59.6%	58.3%
Landfill Gas	7.1	0.2%	0.2%
Solar	12.8	0.3%	0.3%
Wind	203.4	4.8%	4.7%
IML[2]	12.5	0.3%	0.3%

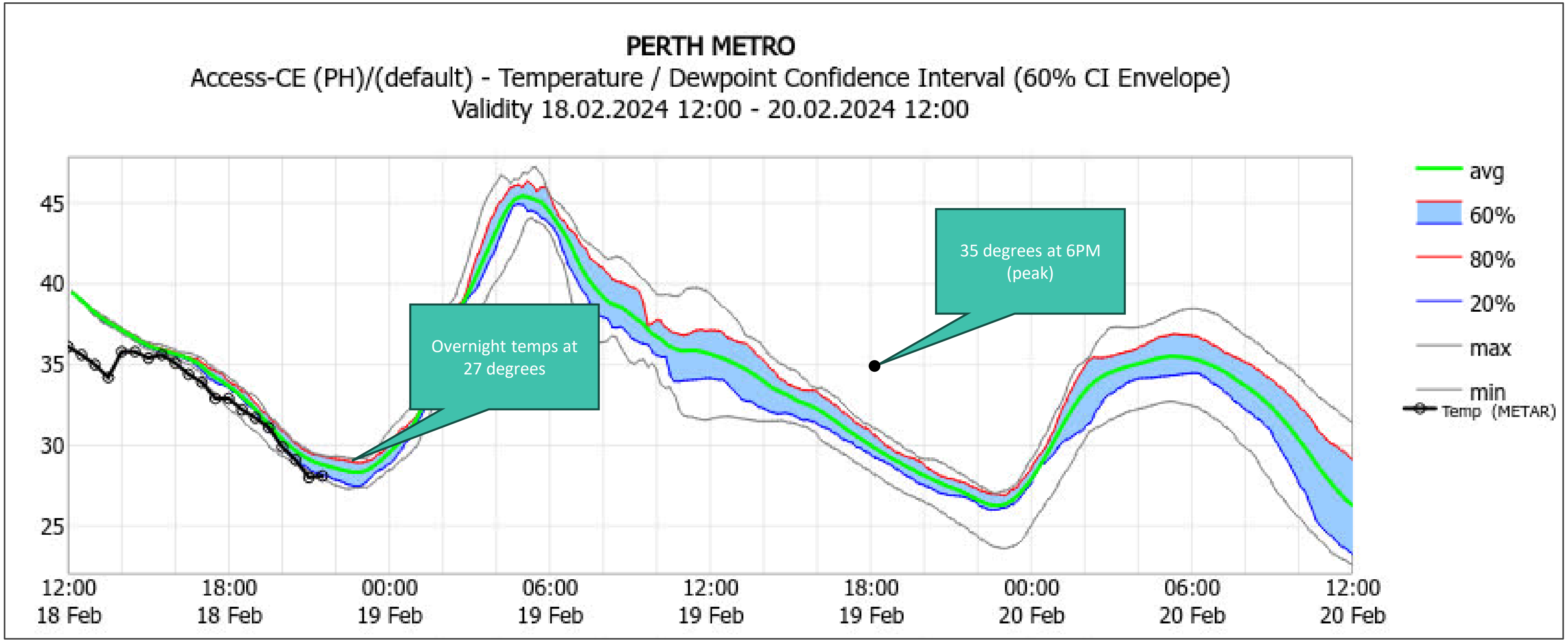
OD = Operational Demand
UD = Underlying Demand
[1]Operational Demand does not include the portion of DPV, this is captured in Underlying Demand
[2]IML includes injection from Intermittent Loads from the Connection Point.

Temperature & Demand Profile Comparison





Explanation of tight conditions



- High overnight temperatures have a large contribution to the following days load forecasts and actuals.
- This effect is referred to as heat banking as households do not get a chance to cool down without the use of air-conditioning, exacerbating the demand for the following day

Operational Update:

Real-Time management of Contingency Raise shortfalls.

Presenter	Leon Kwek

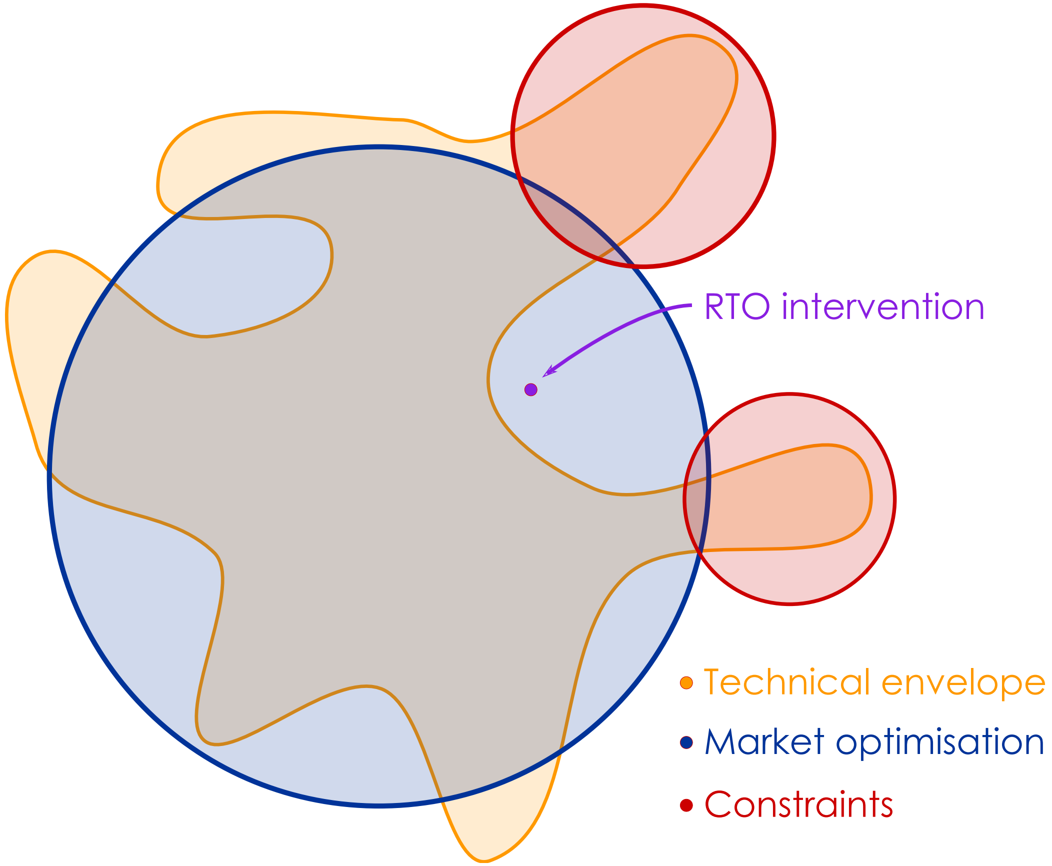
System Operations: Perspectives

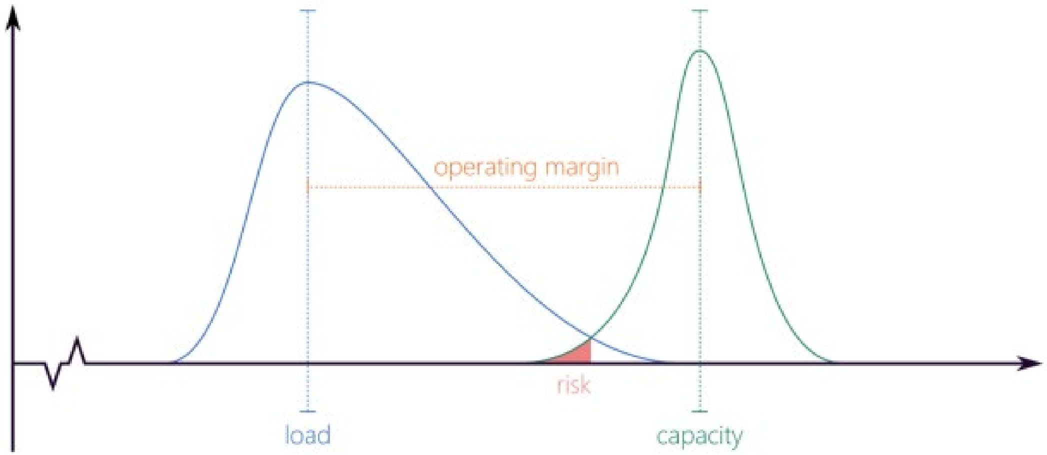
AEMO

Perspective	Power System	Market
Mission	Supply safe and cost-effective electricity to the SWIS	
Objective	Maintain Power System Security / Operate with the technical envelope	Minimise the cost of market dispatch
Real-time problem-space	Is the system: • Secure **right now**? • Returning Secure within 30 minutes?	What is the *optimal dispatch combination* from *all* market offers?

Real-time problem constraints	• Reality / power system physics
	• Limited information and uncertainty
	• Time pressure
	• Human limits:
	    • Communication 'bandwidth'
	    • Operator focus and fatigue
		• Linear optimisation
		• Programmed constraints
		• Regulatory specification
		• Solve time and 5-minute publication window

Models and margins



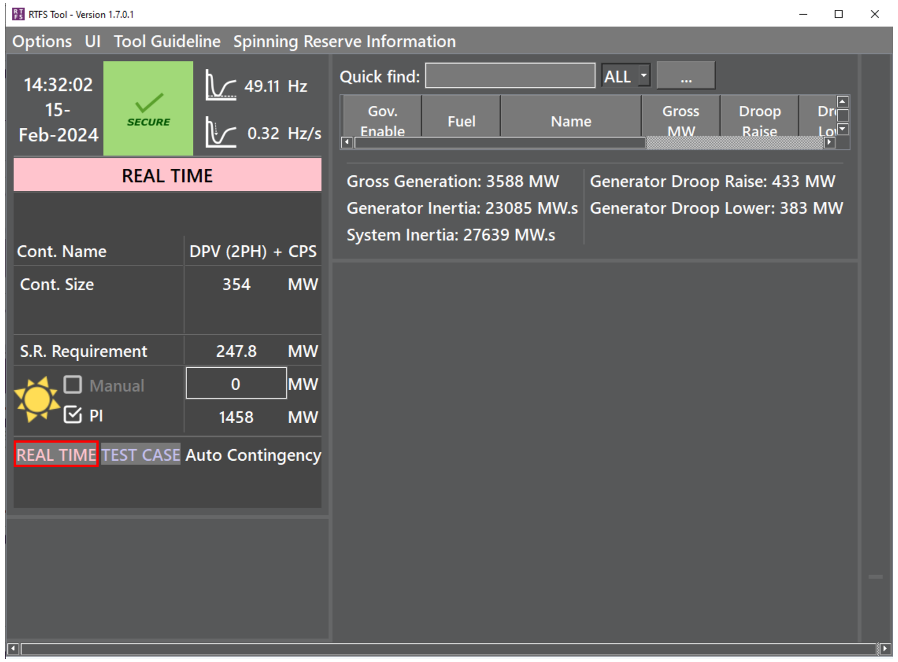


RTFS Tool

- The Real Time Frequency Stability (RTFS) Tool is used by AEMO to assess actual Contingency Raise requirements to avoid the activation of Stage-1 UFLS.
- It allows AEMO to understand system conditions in real-time and how the system will respond to a disturbance by calculating a post-contingency hypothetical frequency nadir, for example, whether sufficient Contingency Raise is available
- This information is used to inform AEMO's determination of what operating state the power system is in.
- Where RTFS indicates the power system is in an insecure state, the controller can take action to rectify to issues and will aim to return to a secure state within 30 minutes.

The RTFS Tool takes the following real time information into consideration:

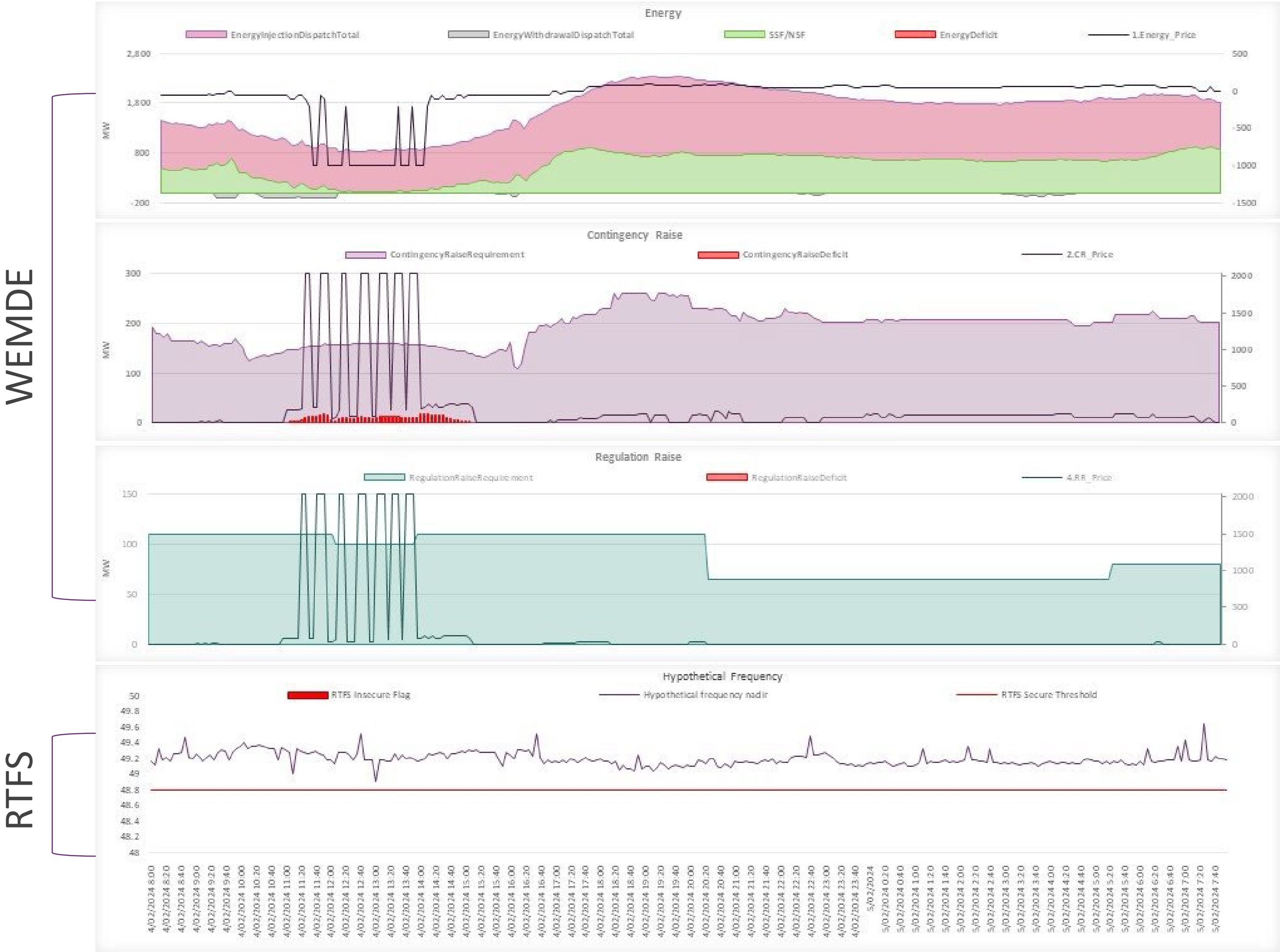
- Contingency Raise providers
- System largest generation/inertia contingency
- System load
- System inertia (RoCoF)
- System frequency
- Governor response of all online generators



System Operations: RTFS and WEMDE

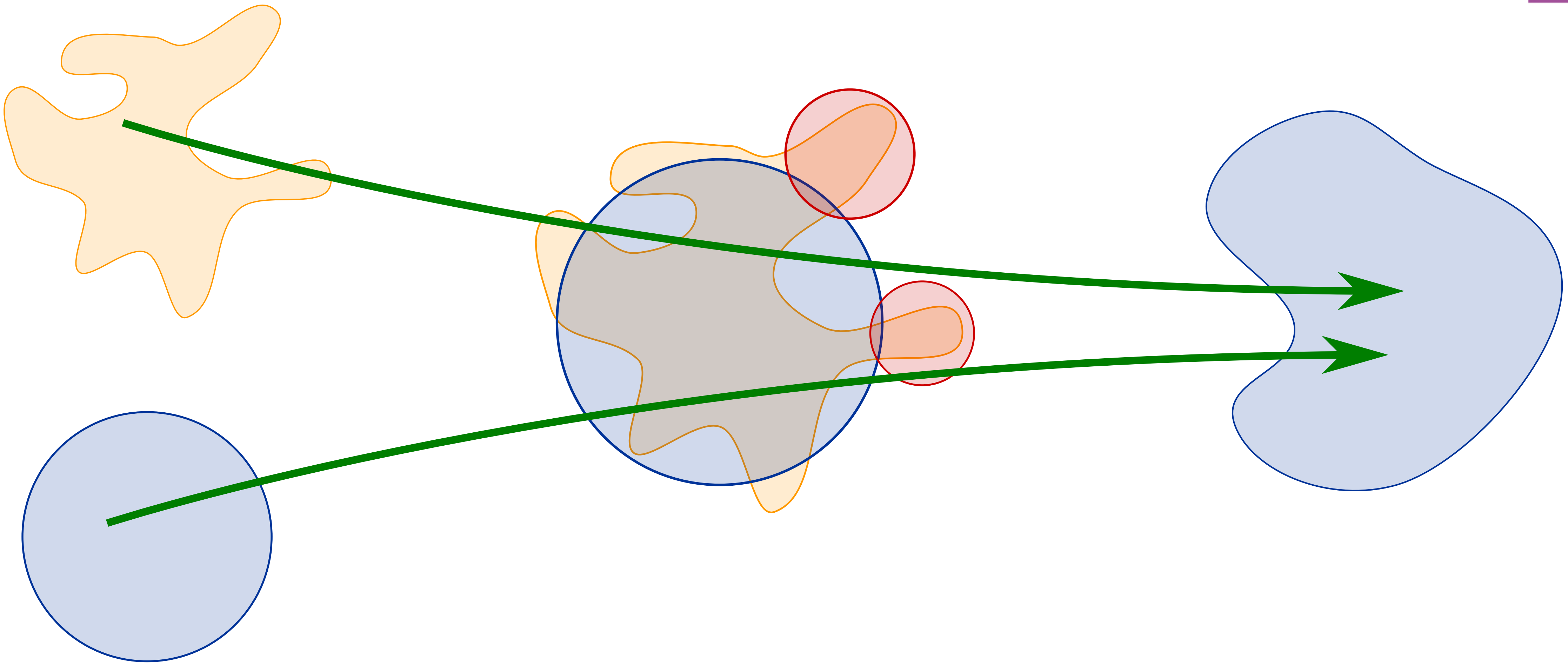
Perspective	Power System	Market
Mission	Dispatch fleet for secure frequency stability	
Software System	Real-time frequency stability tool	WEMDE Dynamic Frequency Stability Model
Base Model	• Dynamic power system simulation • Floating point precision • ~1s refresh	• Pre-simulated look-up table • 20-30 MW precision • 5-minute refresh
Facility model	• SCADA-telemetered limits • Bespoke per-facility representation • Physical capacity enabled	• ESS Accreditation process • SCADA-telemetered trapeziums • Tau and performance factors • Cleared quantities enabled • Separate regulation and contingency capacity
Change governance	• AEMO engineering review • Per-component update	• Full model update • Facility re-accreditation

Alignment of WEMDE and RTFS



- An FCESS Participation Shortfall in WEMDE indicates that insufficient FCESS quantities were, or are forecast to be, available for dispatch in real-time due to a variety of factors including Market Participant submissions, real time generation availability and forecast requirements.
- A shortfall in WEMDE does not necessarily translate to RTFS going insecure as RTFS is based on physical properties of the power system at the time.
- AEMO use RTFS as the primary tool for taking actions to manage Power System Security.

Market Evolution (?)



Investigation:

Distributed PV trips and the connection to the Contingency Raise Requirement.

Presenter	Liam Hayes

Introduction

- A Facility’s contingency size is often greater than the Facility’s setpoint
- This accounts for expected DPV and load loss due to a 2-phase fault at the Facility’s connection point

Solution file example


```json
{
    "facilityCode": "COCKBURN_CCG1",
    "quantity": 240.36
},
```

```json
{
    "id": "DefinedContingencyConstraint NIL * {COCKBURN_CCG1} [LargestContingency]",
    "description": "Defined Contingency Constraint NIL * {COCKBURN_CCG1} [LargestContingency]",
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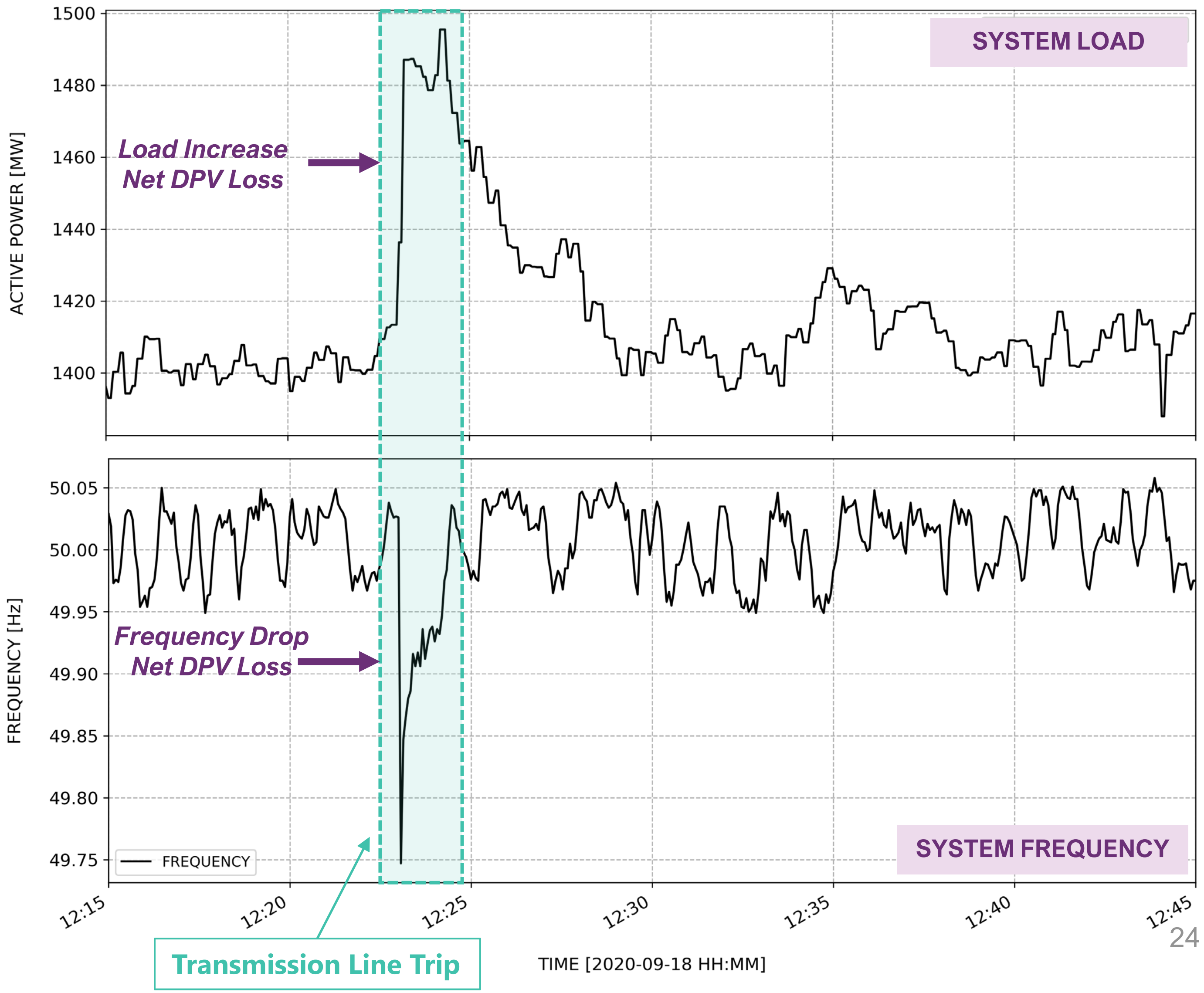
Background

Event Story

- In September 2020, a transmission line trip at around noon resulted in ~100 MW load increase and, in turn, a frequency drop in the system.

- In the past, such an event (i.e. line trips) caused a load drop and increased frequency due to losing more load than DPV (less DPV installed).



Why does DPV trip?

- Inverters not connected on AS/NZS 4777.2 2020 standard are observed to trip (fail to ride through) following a voltage disturbance
- Challenges in predicting loss of DPV:
  - Inverter ride through on old or non-Australian standards is somewhat inconsistent across events
  - Inverter installation even now is not always compliant to the current Australian standard
- Compliance is improving over time, which will help reduce DPV tripping in future

Since then

- AEMO and Western Power have assessed past events to:
  - Analyse estimated DPV and load loss following disturbances
  - Model expected disturbance severity at most locations in SWIS
  - Correlate disturbance severity during actual events to DPV and load loss
  - Form equations to predict DPV and load loss for different fault types and fault locations across the SWIS

For more information see Appendix B of the EPWA Low Load Project Stage 1 Report available at:
https://www.wa.gov.au/system/files/2022-08/EPWA-SWIS%20Low%20Demand%20Project%20Stage%201.pdf

What to expect from AEMO

- AEMO will continue to:
  - Investigate network disturbance to estimate DPV and load loss
  - Use data from investigations to feedback to predictions
  - Adjust DPV and load tripping estimates across SWIS locations as needed
  - Apply the estimates to defined contingencies
  - Investigate other factors that affect likelihood and consequence of contingencies

Investigation:

ESS Pricing and explanation of the ESS Price Ceiling ($2,038)

Presenter	Douglas Birse

Overview

- This presentation is to explain the WEM Market Rules related to price limits and price capping mechanism.
- An example is included to show an interval where at least one of the Market Clearing Price was capped and set equal to the ceiling for that service. This example is helpful to explain when and why prices higher than the ceiling may occur.

Offer price limits and price caps

- Market Price Limits: for each Market Service there are offer price limits (ceiling and floor) set and reviewed by the ERA in accordance with section 2.26 of the WEM Rules.
- An Offer Price Ceiling (Floor) is the maximum (minimum) price that may be associated with a RTM submission for provision of that specific service.
- FCESS only have an Offer Price Ceilings, while the floor is always 0.
- The current Offer Price Limits are:
  - Energy Offer Price Ceiling: 738 $/MWh
  - Energy Offer Price Floor: -1000 S/MWh
  - FCESS Offer Price Ceiling: 300 $/MW per hour ($/MWs per hour for RoCoF)

Offer price limits and price caps

- According to WEM Rules 7.11B.3A and B, for any Dispatch Interval:
  - If the Energy Market Clearing Price determined by WEMDE is:
    - < Energy Offer Price Floor, then the Energy Market Clearing Price is set equal to the Energy Offer Price Floor (currently -$1000/MWh)
    - > Energy Offer Price Ceiling, then the Energy Market Clearing Price is set equal to the Energy Offer Price Ceiling (currently $738/MWh)
  - If a FCESS Market Clearing Price determined by WEMDE is:
    - <0, then the FCESS Market Clearing Price is set equal to zero
    - > FCESS Clearing Price Ceiling, then the FCESS Market Clearing Price is set equal to the **FCESS Clearing Price Ceiling:**

$$Energy\ Offer\ Price\ Ceiling - Energy\ Offer\ Price\ Floor + FCESS\ Offer\ Price\ Ceiling$$

$$currently, for\ all\ FCESS,$$

$$738 - (-1000) + 300 = \mathbf{2038}$$

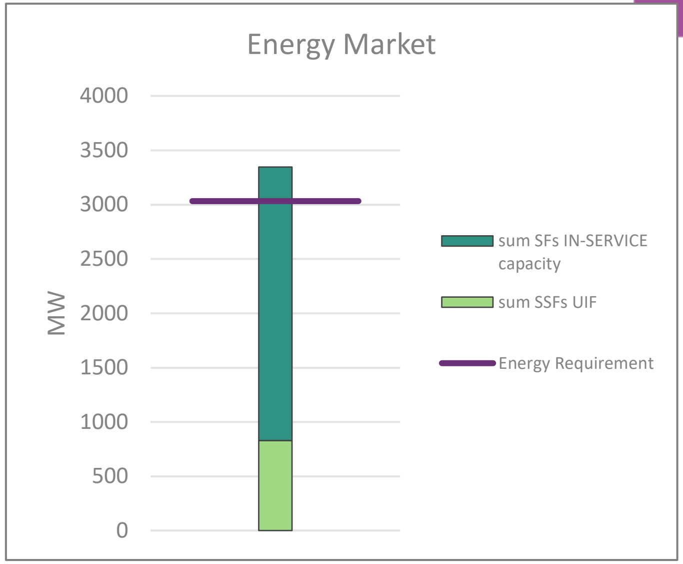
Intervals clearing at the FCESS price cap

- FCESS Clearing Price Ceilings have been observed several times both in intervals with FCESS shortfalls and intervals without shortfalls.
  - Under a shortfall the Over-Constrained Dispatch Run Process is followed, see WEM Procedure: Dispatch Algorithm Formulation for the full explanation
- Tight conditions (in raise or lower markets) combined with high energy market price contributions or low Performance Factors are generally the main driver to FCESS prices clearing at the ceiling. In these situations, the WEMDE price setting mechanism works at the edges.
- In some of these cases, the *byHowMuch* coefficients of price contributions may not have a physical meaning but only mathematical.

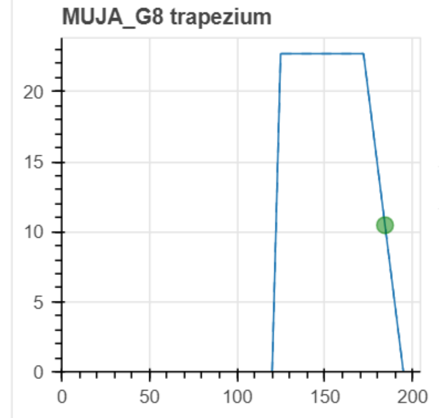
Dispatch Interval 2023-12-19 18:40

Background

- On this interval conditions in Energy and raise services were tight, despite not ending in shortfalls.
- Almost all the IN-SERVICE capacity in Energy was used.
- All facilities providing capacity in raise services are working at the boundaries of their trapezia (joint capacity constraints binding): increase in one service means trade-offs in other services.



Example Joint Capacity Constraint 1 binding for MUJA_G8 - Contingency Raise



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Background

- Under these tight conditions, the increase in the marginal tranche for raise services to set the price leads to a series of trade-offs.
- For Contingency Raise, there is no capacity available for increasing the marginal tranche and WEMDE selects a price setting combination that starts with the marginal decrease of the requirement by decreasing the size of the largest contingency (COLLIE). This is possible because the Contingency Raise requirement is calculated by the engine instead of being an external input.
- For Energy and Regulation Raise, instead, the increase of the marginal tranche is followed by a series of trade-off that in both cases lead to the need of a marginal decrease of the largest contingency (to decrease the Contingency Raise requirement).
- Since the largest contingency is COLLIE with a -$1000/MWh tranche in Energy, the marginal decrease on its energy setpoint means a price contribution with an objective coefficient of -1000 and a negative byHowMuch coefficient. This causes a large contribution in setting the price and the need for capping the final price.

Dispatch Interval 2023-12-19 18:40

Price setting contributions for Contingency Raise

Contribution	By How Much	Objective Coefficient	byHowMuch * objectiveCoeff
COLLIE_G1_energy_Tranche_01	-1.8083	-1000	1808.318
PINJAR_GT7_energy_Tranche_01	1.8083	131.82	238.3725
PINJAR_GT7_regulationLower_Tranche_01	1.8083	0	0
KWINANA_GT3_regulationLower_Tranche_01	-0.9042	0	0
KWINANA_GT2_regulationLower_Tranche_01	-0.9042		
PINJAR_GT7_regulationRaise_Tranche_01	-1.8083	0	0
KEMERTON_GT11_regulationRaise_Tranche_01	1.8083	0	0
KEMERTON_GT11_contingencyRaise_Tranche_01	-1.8083	0.0001	-0.00018
Total			**2046.691** >2038


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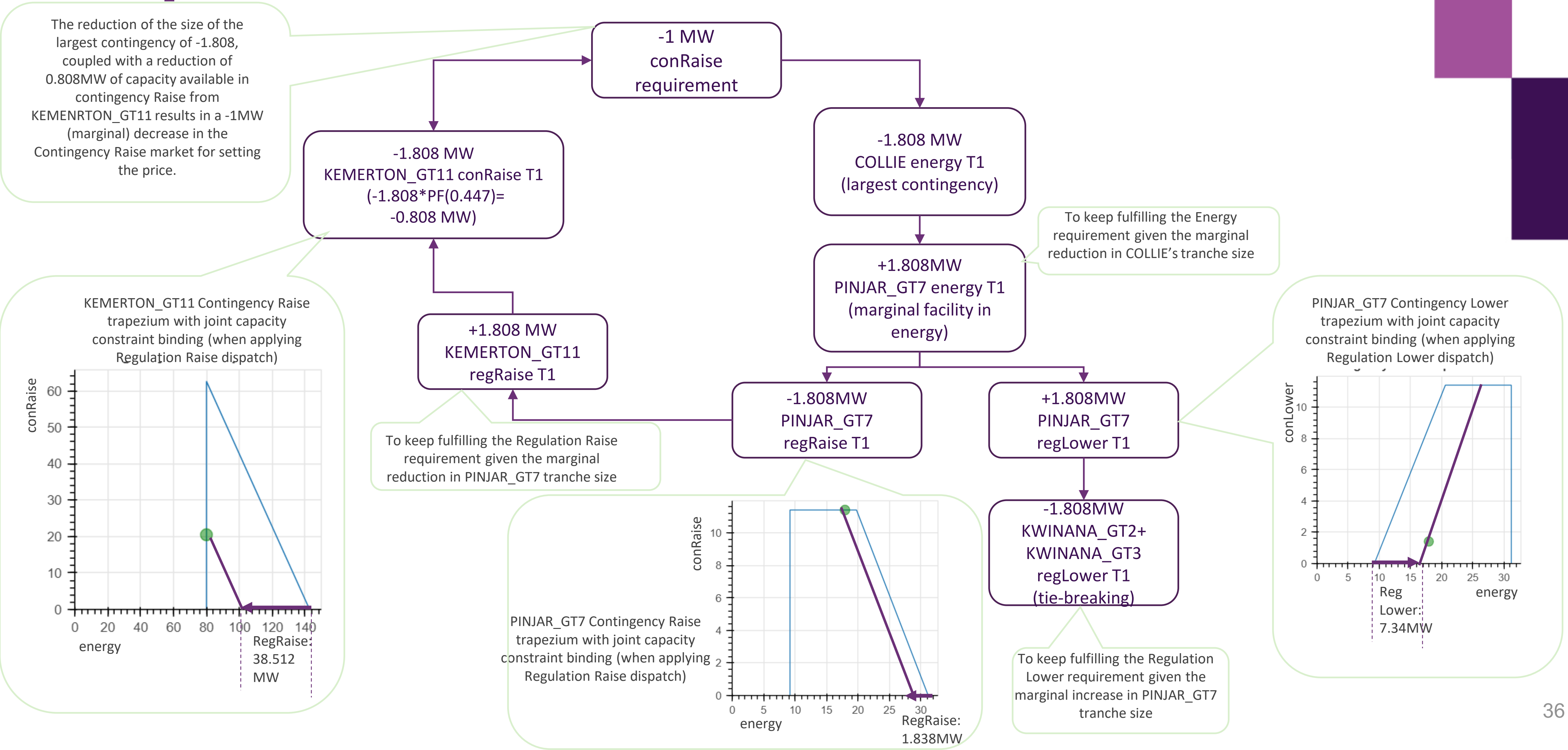

Summary

- ESS Clearing Price Ceiling is set at:

$$Energy\ Offer\ Price\ Ceiling - Energy\ Offer\ Price\ Floor + FCESS\ Offer\ Price\ Ceiling$$

$$currently, for\ all\ FCESS,$$

$$738 - (-1000) + 300 = \mathbf{2038}$$

- This can be reached under very tight market conditions where the margin price setting comprises a combination of:
  - Low or High Energy Prices Contributions
  - Lower Performance Factors of Contingency Raise Providers
- These dynamics do not only apply to ESS Prices at the Clearing Price Ceiling

Operational Update:

System Updates

Presenter	Various

Data Retention Policy

Production

- Retain all

Pre-Production / RFM

- Retain data when:
  - <30 days since creation:
    - all
  - >30 days since creation:
    - RunPosition = 1
    - RunType = Dispatch
    - Scenario = Reference

Please provide feedback to wa.rtm@aemo.com.au

FCESS Uplift Payments

- Fix deployed last Wednesday 14 February, impacting inputs to FCESS Uplift Payment calculations.
- Changes reflected in Prudential calculations and all future invoices.
- The following Adjustment Invoices are impacted:
  - Adjustment 1 Invoices for TW 24 Dec 2023 – TW 14 Jan 2024
  - Adjustment 2 Invoices for TW 01 Oct 2023 – TW 17 Dec 2023
- Contact wa.settlements@aemo.com.au with any questions.

WEMDE 2.0 Release Notes
https://aemo.com.au/en/energy-systems/market-it-systems/it-change-and-release-management

Questions, Feedback, Ideas

wa.rtm@aemo.com.au

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