# ST PASA Replacement Technical Workshop 3

11 May 2026

Forecast Stack Methodology & Walkthrough

Public

**We acknowledge the Traditional Custodians of the land, seas and waters across Australia. We honour the wisdom of Aboriginal and Torres Strait Islander Elders past and present and embrace future generations.**

We acknowledge that, wherever we work, we do so on Aboriginal and Torres Strait Islander lands. We pay respect to the world's oldest continuing culture and First Nations peoples' deep and continuing connection to Country, and hope that our work can benefit both people and Country.

**'Journey of unity: AEMO's Reconciliation Path' by Lani Balzan**

AEMO Group is proud to have launched its first Reconciliation Action Plan in May 2024. 'Journey of unity: AEMO's Reconciliation Path' was created by Wiradjuri artist Lani Balzan to visually narrate our ongoing journey towards reconciliation – a collaborative endeavour that honours First Nations cultures, fosters mutual understanding, and paves the way for a brighter, more inclusive future.

*Read our RAP*



Public

# General Housekeeping

1. Please mute your microphone when not speaking.
2. We look forward to your feedback and questions. Questions are welcome throughout the session, either in the chat or by raising a virtual hand. Alternatively, you can raise your questions during the Q&A.
3. In attending this meeting, you are expected to:
   - Contribute constructively.
   - Be respectful, both on the call and in the chat.

Participants are asked to familiarise themselves with AEMO's Competition Law Meeting Protocol and AEMO's forum expectations as outlined in Appendix A.

# Presenters

- **Brian Nelson** Specialist, Operations
- **Andrew Akman** Principal Data Scientist, Operations
- **Hill Zhou** Data Scientist, Operations
- **Steven Disano** Specialist Data Scientist, Operations (Modelling SME)

# Agenda

| # | Time (AEST) | Topic | Presenters |
|---|---|---|---|
| 1 | 10:00am – 10:05am | **Welcome and objectives** | Lenard Bayne |
| 2 | 10:05am – 10:15am | **Background and context** | Brian Nelson |
| 3 | 10:25am – 11:25am | **Matters for discussion**<br>➢ Key definitions<br>➢ How Uncertainty moves into new PASA<br>➢ The Forecast stack<br>➢ Forecast Stack Validation | Andrew Akman, Steven Disano & Hill Zhou |
| 4 | 11:25am – 11:30am | **Delivery roadmap and key dates** | Brian Nelson |
| | 11:30am | **Workshop Close** | |

**Appendix A:** AEMO Competition Law - Meeting Protocol

*"Please note that this meeting will be recorded by AEMO and may be accessed and used by AEMO for the purpose of compiling minutes. By attending the meeting, you consent to AEMO recording the meeting and using the record for this purpose. No other recording of the meeting is permitted"*

# 2. Background and context

Brian Nelson – AEMO

# Project status

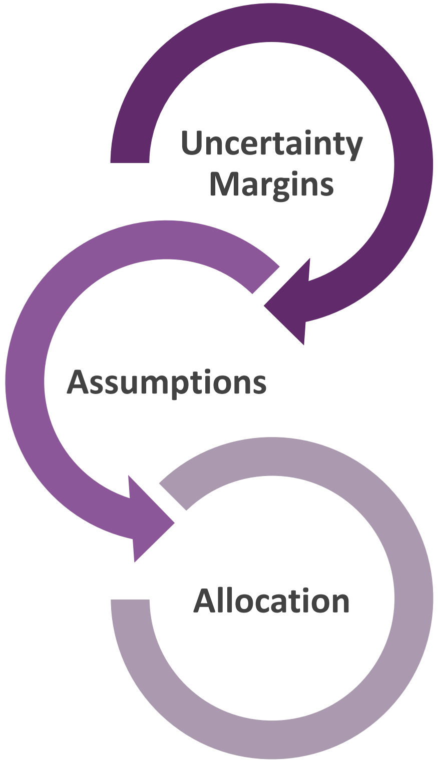
- Consultation 2 Draft Report is currently open for submissions
  - This workshop is partly intended to inform submissions relating to forecasting

- At the Program Consultative Forum on 23 April, AEMO advised of a phased approach to commencement of the new ST PASA
  - **Phase 1:** – internal release based on PD PASA operation for production evaluation (August 2026)
  - **Phase 2:** – second release and parallel run period
  - **Phase 3:** – third release and commencement

# Workshop Objectives

**This workshop covers the ST PASA forecasting infrastructure and its associated processes**.

AEMO acknowledge the concerns highlighted in consultation submissions and previous workshops:




Uncertainty margins for different technologies

Assumptions risks in historical data use

Allocation of demand response to nodes, zones, and regions

# 3 Matters for discussion

Andrew Akman – AEMO
Steven Disano – AEMO
Hill Zhou – AEMO

# Key Definitions

# The Forecast Stack – Definitions (1 of 4)

## Forecast Stack

The Forecast Stack is the forecasting layer of the new PASA system. It takes forecast, market and network-related inputs and converts them into the structured input files required by the downstream PASA Engine.

**It plays three key roles:**

**Forecasting**

- Run machine learning forecast models for demand, generation and related inputs across the NEM.

**Uncertainty adjustment**

- Applies POE-based uncertainty settings so demand and generation can be represented under different levels of forecast uncertainty.

**PASA input preparation**

- Produces PASA-ready generation and demand outputs, including adjusted BidMaxAvail, load forecasts, power factor information and other required input files.

# The Forecast Stack – Definitions (2 of 4)

## PASA Engine

AEMO's core optimisation solver used in the new ST PASA system to run a security-constrained economic dispatch (SCED) over the PD & ST PASA outlook. It combines forecast inputs (demand and generation), market bids, and network constraints (including outages and contingencies) to produce a feasible dispatch solution and identify any projected shortfalls (deficits).

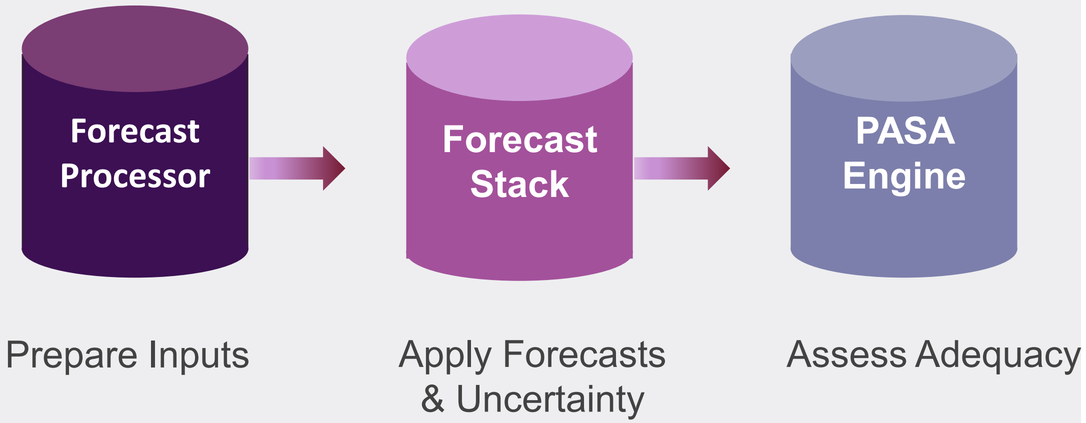

**It is responsible for:**

- Running the security-constrained dispatch assessment
- Applying network and contingency constraints
- Identifying projected deficits, reserve levels and LOR-related outcomes

## Forecast Stack

The Forecast Stack sits between forecast preparation layer and the PASA Engine, converting upstream inputs into engine-ready forecasts.

The PASA Engine then uses those forecasts to assess future system adequacy and identify potential reserve risks.



# The Forecast Stack – Definitions (3 of 4)

## Uncertainty Margins

MW amounts representing expected conditional forecast error at a specified confidence level (e.g. 95% PoE).

**How Applied:**

- Demand → Add margin
- VRE → Subtract margin
- Scheduled Gen Max Avail → Subtract margin

Regional total calculated first, then scaled to individuals so sum meets regional total (allows error cancellation).

## Probability of Estimate

Probability of Estimate (percentile / confidence level) that sets the size of Uncertainty Margins. A higher POE means a larger margin is applied to allow for greater forecast uncertainty.

**Example:**

POE95 means the margin is sized so that actual outcomes are expected to fall within the margin **95%** of the time.

**Note on Demand:**

Demand uses the opposite side of the distribution to generation. For example, a generation ***POE95*** margin is subtracted from supply, while the equivalent demand case adds the ***POE5*** margin to demand.

*95% used as an example. More on POE and Margin Distributions in next section*

# The Forecast Stack – Definitions (4 of 4)

## Node Point (load point)

A specific bus-bar location in AEMO's full network model representing a grid exit point where demand is withdrawn from the transmission network.

**Key Facts:**

- > 1,700 nodal points (feeders) across the NEM (heavily concentrated in NSW & QLD)
- Required because SCED/PASA solves on the full nodal network model with transmission constraints

Demand forecasts must be produced at this granular level (not just regional totals).

## Disaggregation

This process takes a top-down forecast and breaks it down into more granular-level values needed by the full-network model.

**Two Main Applications:**

Demand: Regional operational demand forecast → proportional nodal loads

Uncertainty Margins: Regional uncertainty total → proportional unit/node margins

Ensures we meet nodal network modelling requirements while remaining consistent with any regional (top-down) forecasts.

# How Uncertainty moves into new PASA

# How uncertainty moves into the new PASA workflow

The new Forecast Stack is intended to move uncertainty treatment from a largely reserve-setting / post-solver mechanism (FUM) into the pre-processing PASA workflow. This means uncertainty can now be represented directly in the demand and supply inputs used by the new PASA engine solver.

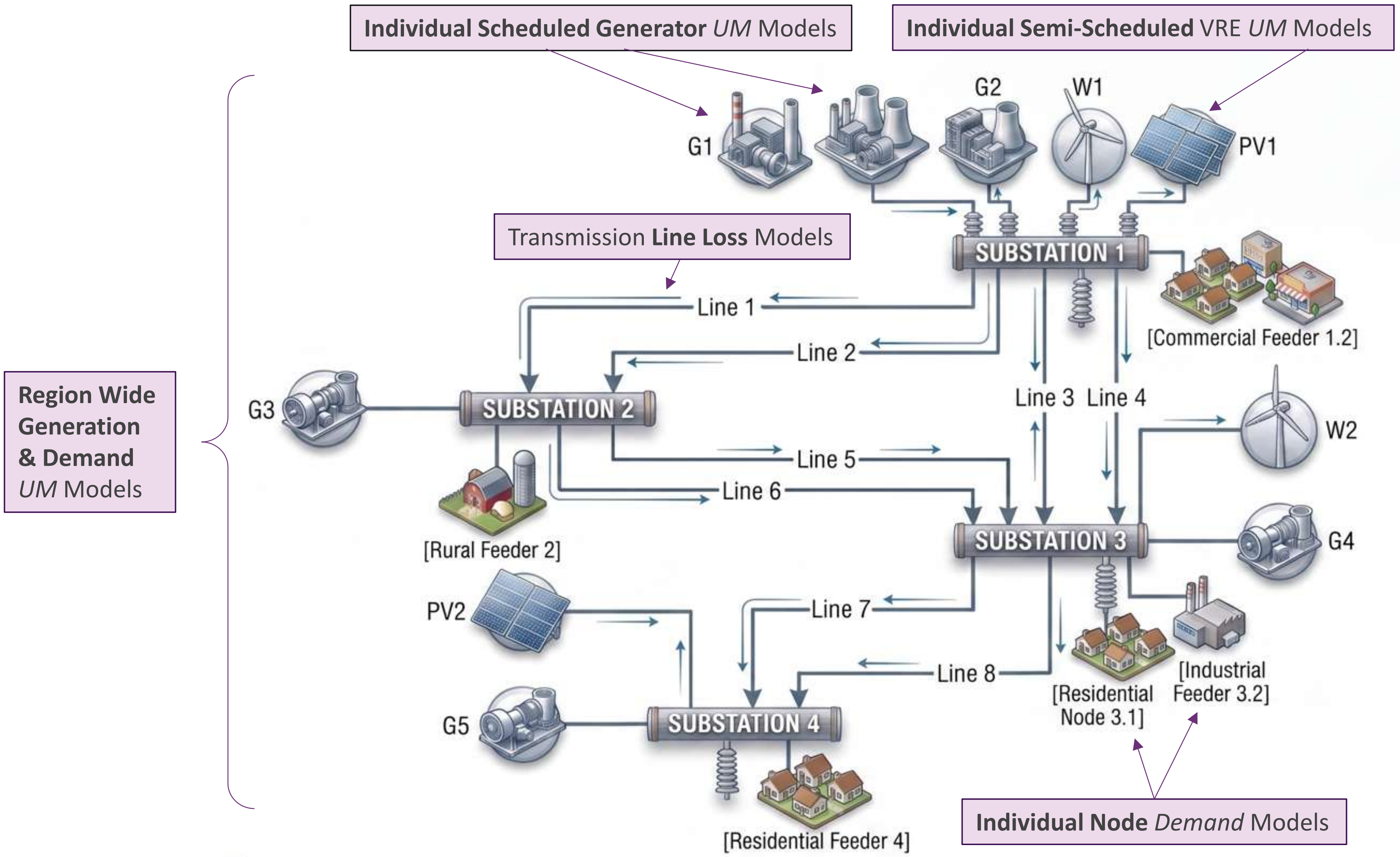
| | FUM (Current) | Forecast Stack (Future) |
|---|---|---|
| **Uncertainty Objective** | Designed to account for forecast uncertainty to help support dynamic reserve assessment at a regional level in current PASA. | Designed to bring uncertainty directly into the core PASA workflow by preparing uncertainty-adjusted demand and supply inputs before the PASA engine runs. It also supports a more physically representative nodal view of the system. |
| **Level of modelling** | **Regional Level**<br>FUM is assessed to determine excess supply (RXS) in each region. | **Nodal / Unit Level**<br>Demand is modelled at load point / node level, and supply at generator / generation site / unit level. |
| **How it is used** | Applied **after** the current PASA optimisation to determine LOR trigger levels / reserve thresholds for the region. | Forecast Stack becomes a core application in the new ST PASA system. Applied during each PASA run by adjusting demand forecasts and resource capacities **before** they are passed into the engine. |

# The Forecast Stack

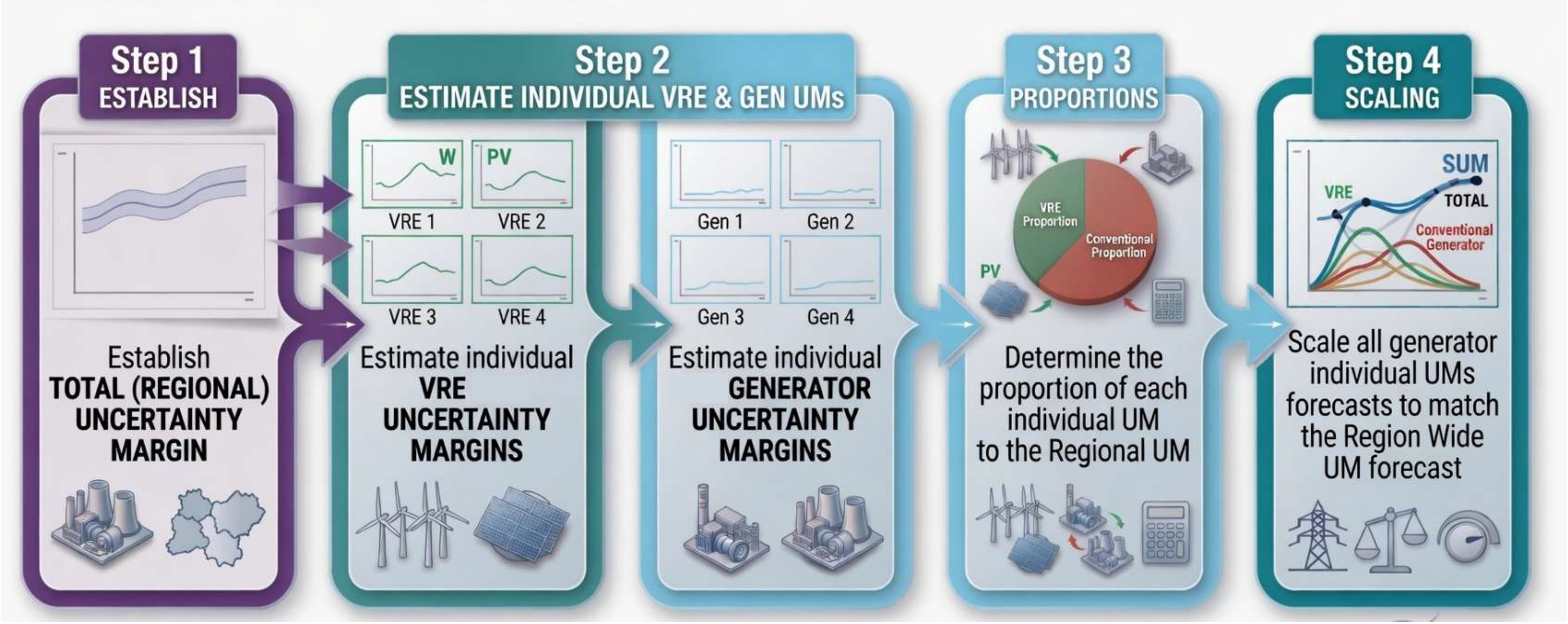
# Generation Forecasting Methodology Overview

Public

# The Forecast Stack – Top-Down View

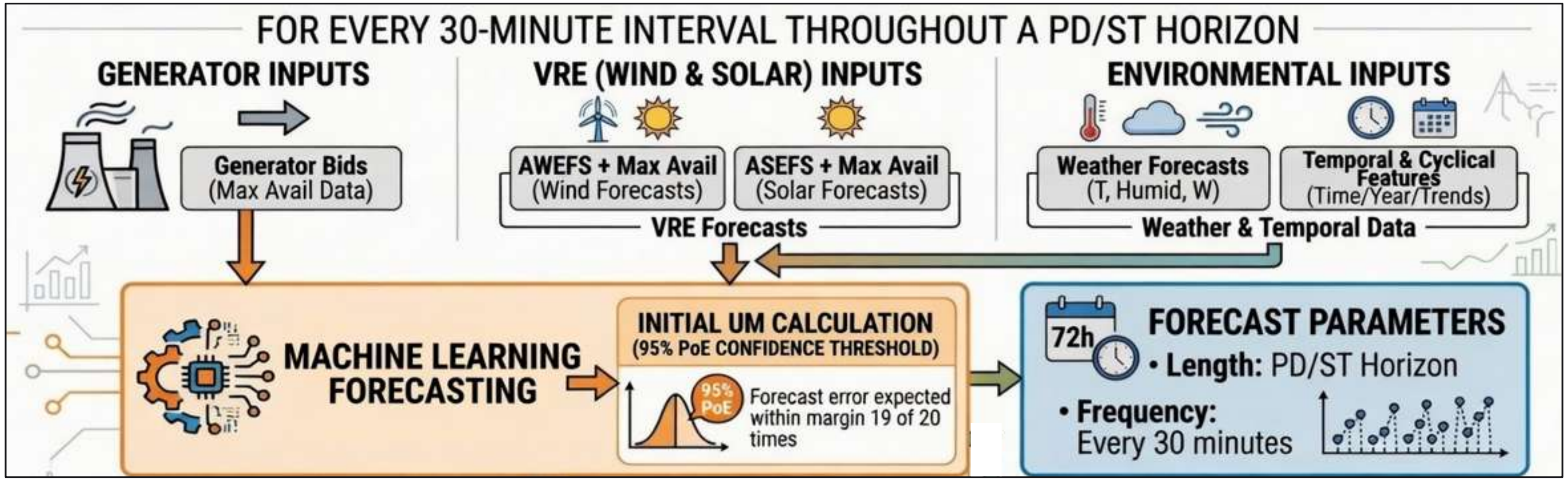


# Forecast Stack - Generation Methodology



# Generator Forecasting Methodology

## Used for Regional and Individual Generators




**Uncertainty Margin (UM) Model Training Pipeline:**

*i.* ***Region Wide Level*** calculated from regional generation and uncertainty

*ii.* ***Wind and Solar*** generators based on AWEFS & ASEFS or Max Avail forecasts

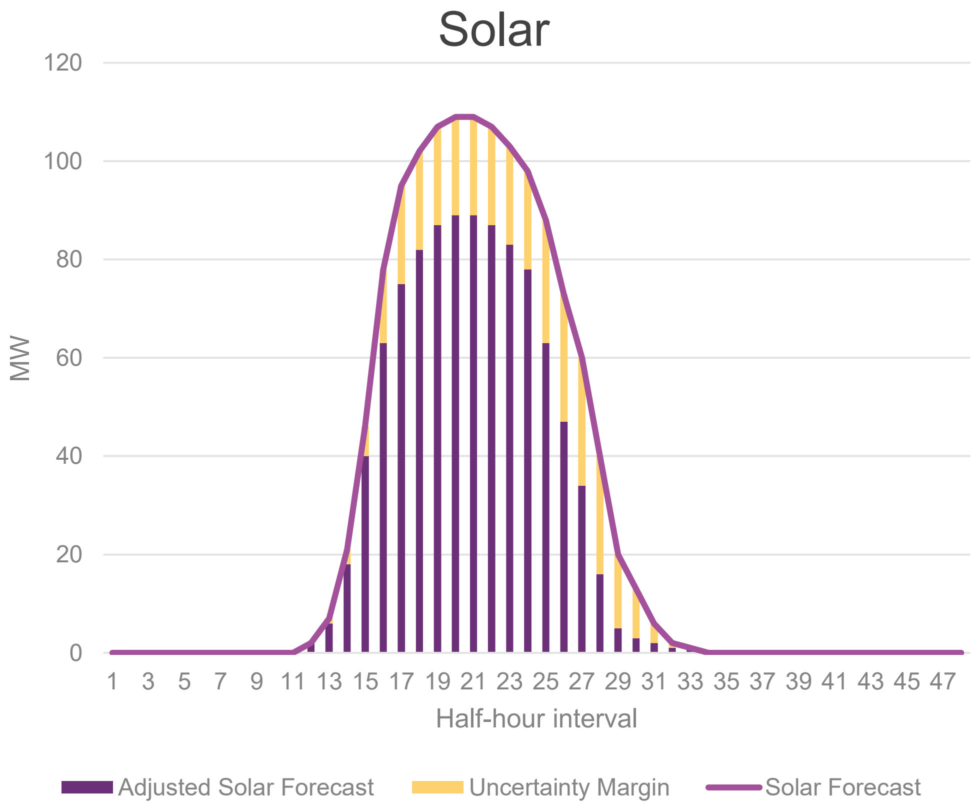
*iii.* ***Scheduled*** generators based on Max Avail from bids

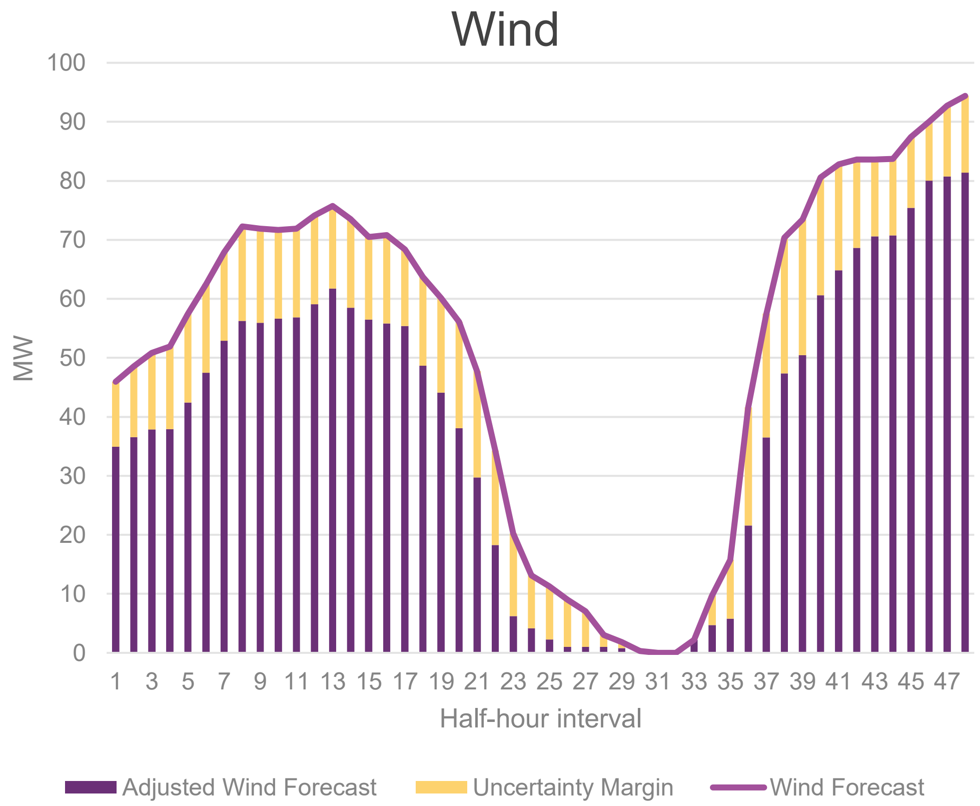
- Machine learning models to predict UM – ***using quantile regression***
- Standardised set of features for all models. (Standardization greatly improves model training and model scoring)
- Various PoE levels are being actively assessed (i.e. PoE 50%, 60%, 70%, 80%, 85%, 90%, 95%, 99%)
- Models predict UM for every 30-minute interval for PD/ST horizon
- Over 500 individual Generator Models were trained and deployed

# Generator Uncertainty Adjustment

## Used for Regional and Individual Generators

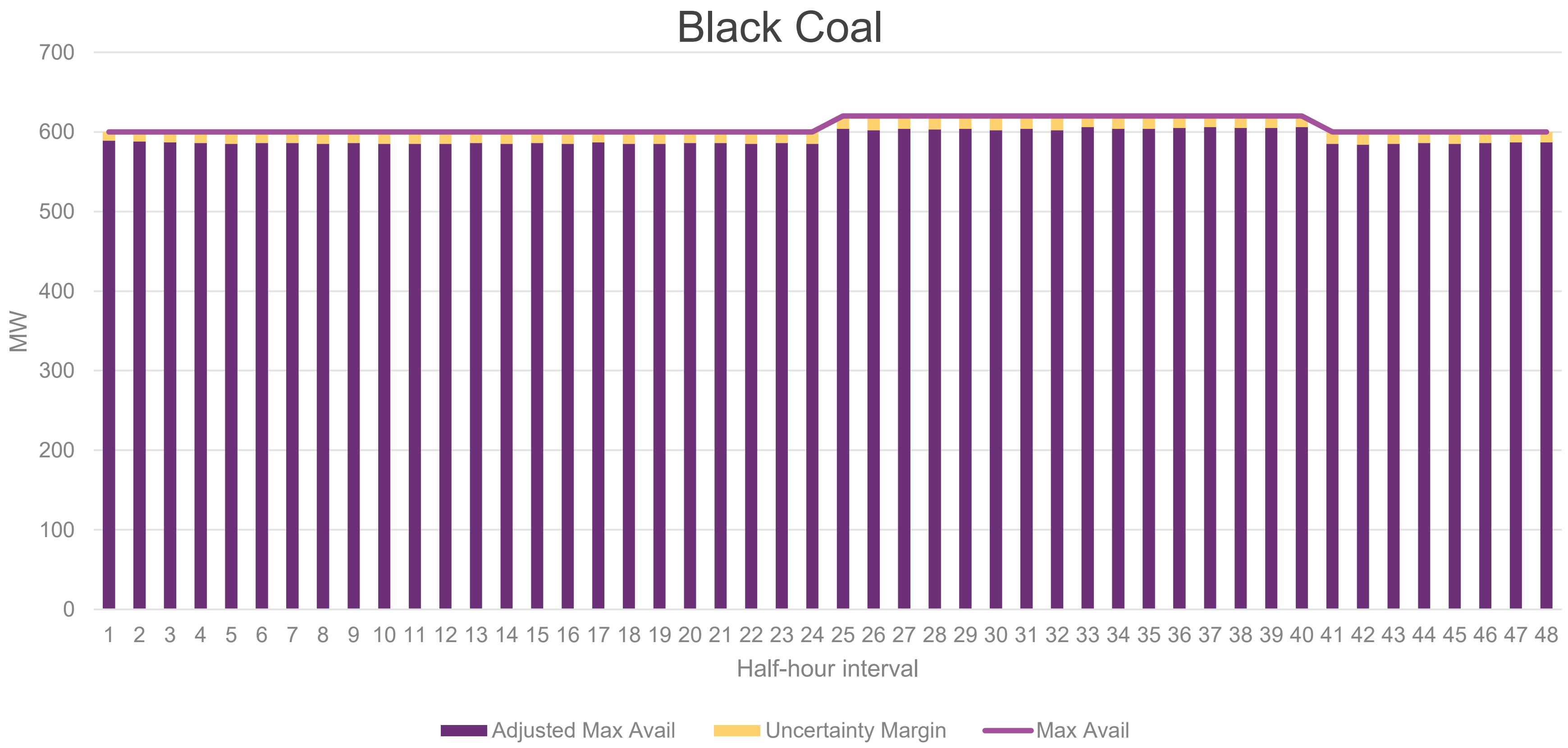
Adjust the VRE forecast (greater of AWEFS/ASEFS or MaxAvail) by **subtracting** the Uncertainty Margin. (i.e. we reduce expected generation)



# Generator Uncertainty Adjustment
## Used for Regional and Individual Generators

Adjust the Scheduled generator forecast (MaxAvail) by **subtracting** the Uncertainty Margin. (i.e. we reduce expected generation)

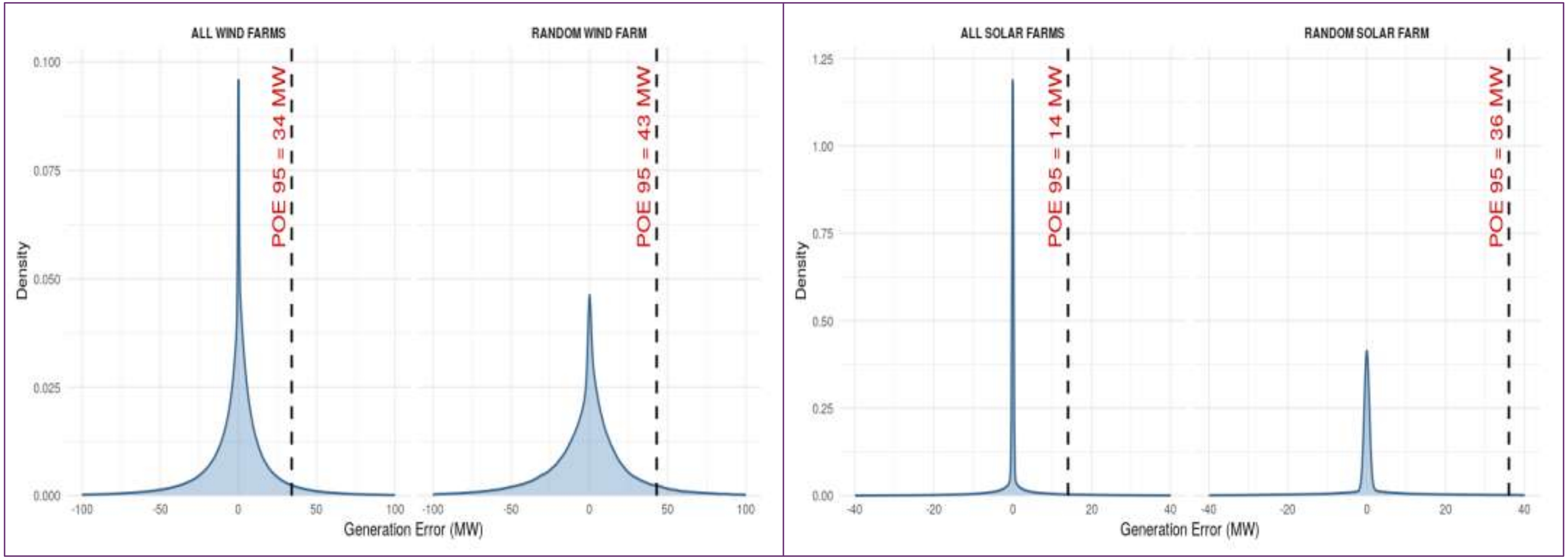


# Generator Methodology

## Estimating Individual VRE Uncertainty Margins

**Uncertainty margin increases with:**

1. Installed capacity
2. Longer horizons
3. Weather uncertainty
4. Individual Historical Reliability




**Key Takeaways:**

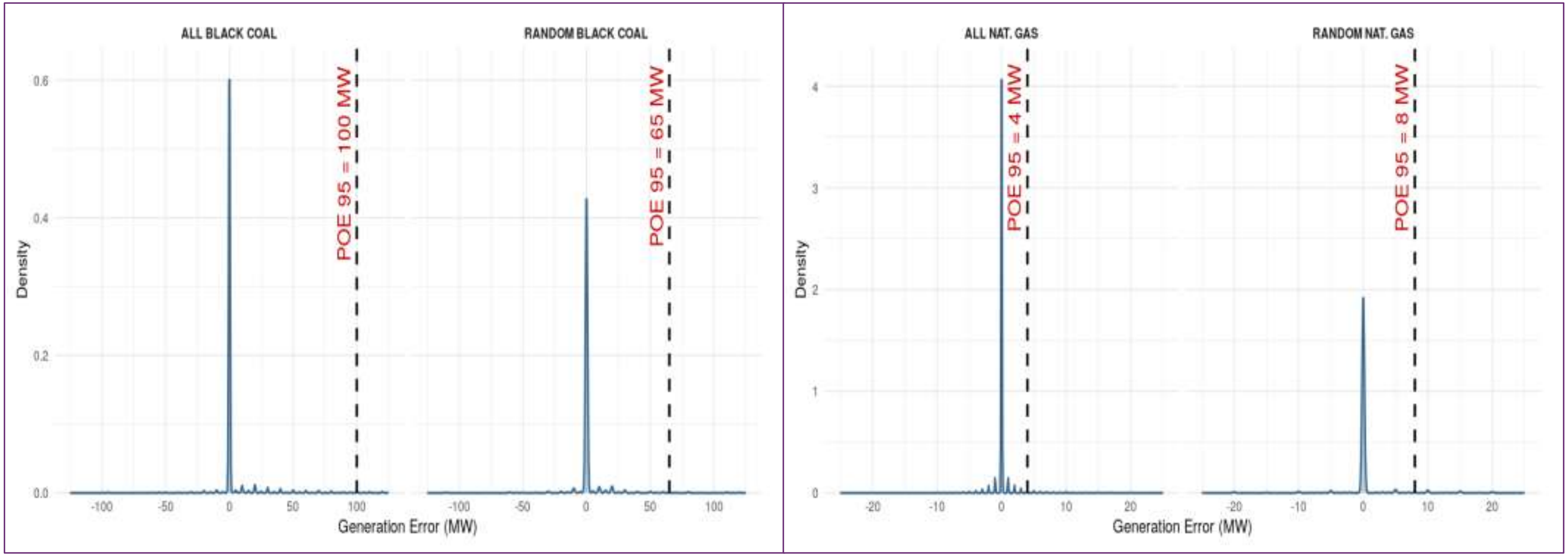
1. Wind and Solar have very different UM distributions
2. Individual Farms can have very different UM distributions relative to the average farm of the same fuel type

# Generator Methodology

## Estimating Individual Generator Uncertainty Margins

**Uncertainty margin increases with:**

1. Installed capacity
2. Longer horizons
3. Weather uncertainty
4. Individual Historical Reliability

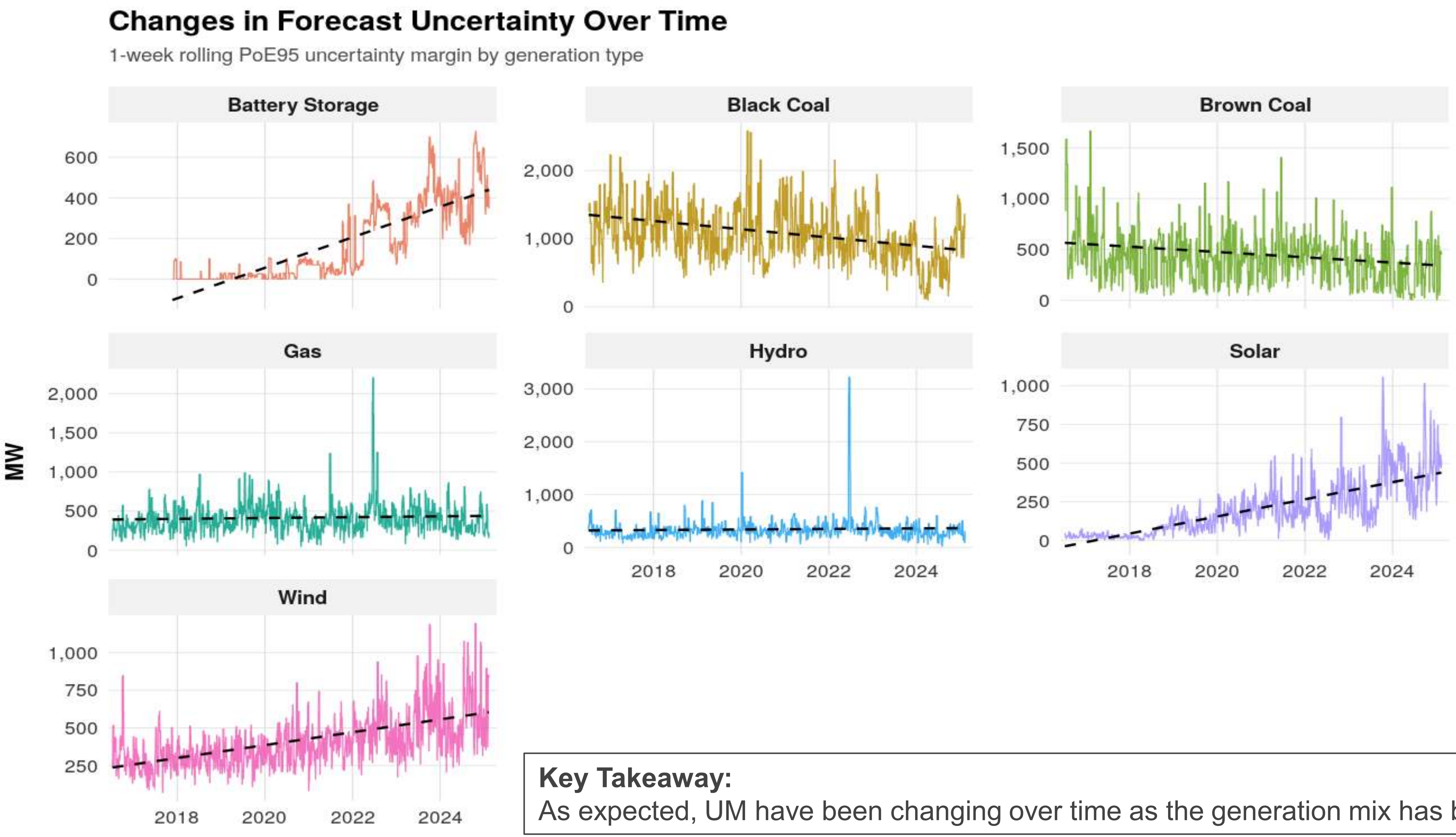



**Key Takeaways:**

1. Scheduled Generator have very different UM distributions across fuel types
2. Individual Scheduled Generators can have very different UM distributions relative to the average generator of the same fuel type

# Generation Methodology

## Insights – Uncertainty Margins since 2017




**Key Takeaway:**
As expected, UM have been changing over time as the generation mix has been evolving



Public

# Demand Forecasting Methodology Overview

# Demand Methodology

## From Generator to Substation

### Step 1: Operational Demand Forecast

(This is generations dispatched into the power grid)

This is where AEMO's Operational Forecasting System sits

### Step 2: Add Region-Wide Uncertainty Margin

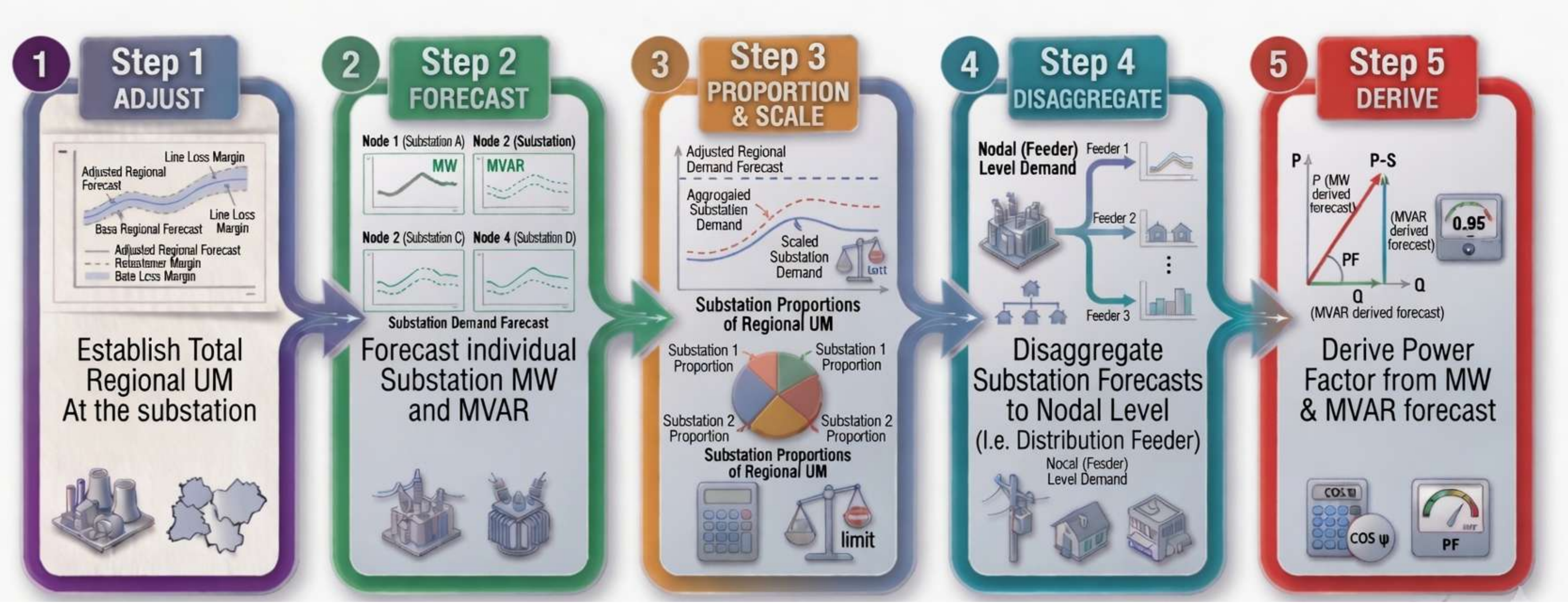
### Step 3: Subtract Region-Wide Network Losses

### Step 4: Estimated Operational Demand Forecast at the Substations

This forecast introduces a region wide cap that the individual substation forecasts will not exceed

# Demand Methodology

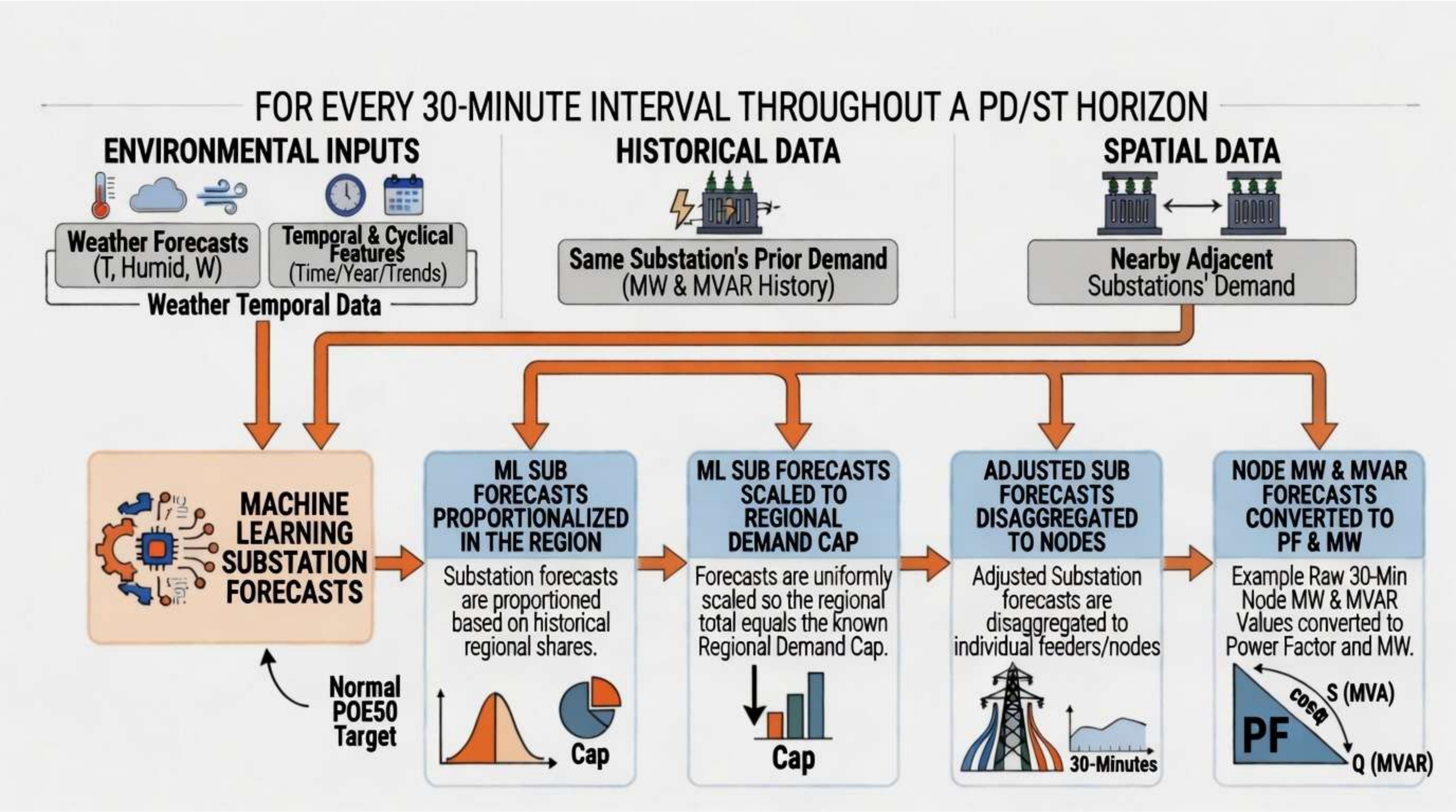
## From Substation to Node (Feeder)






Public

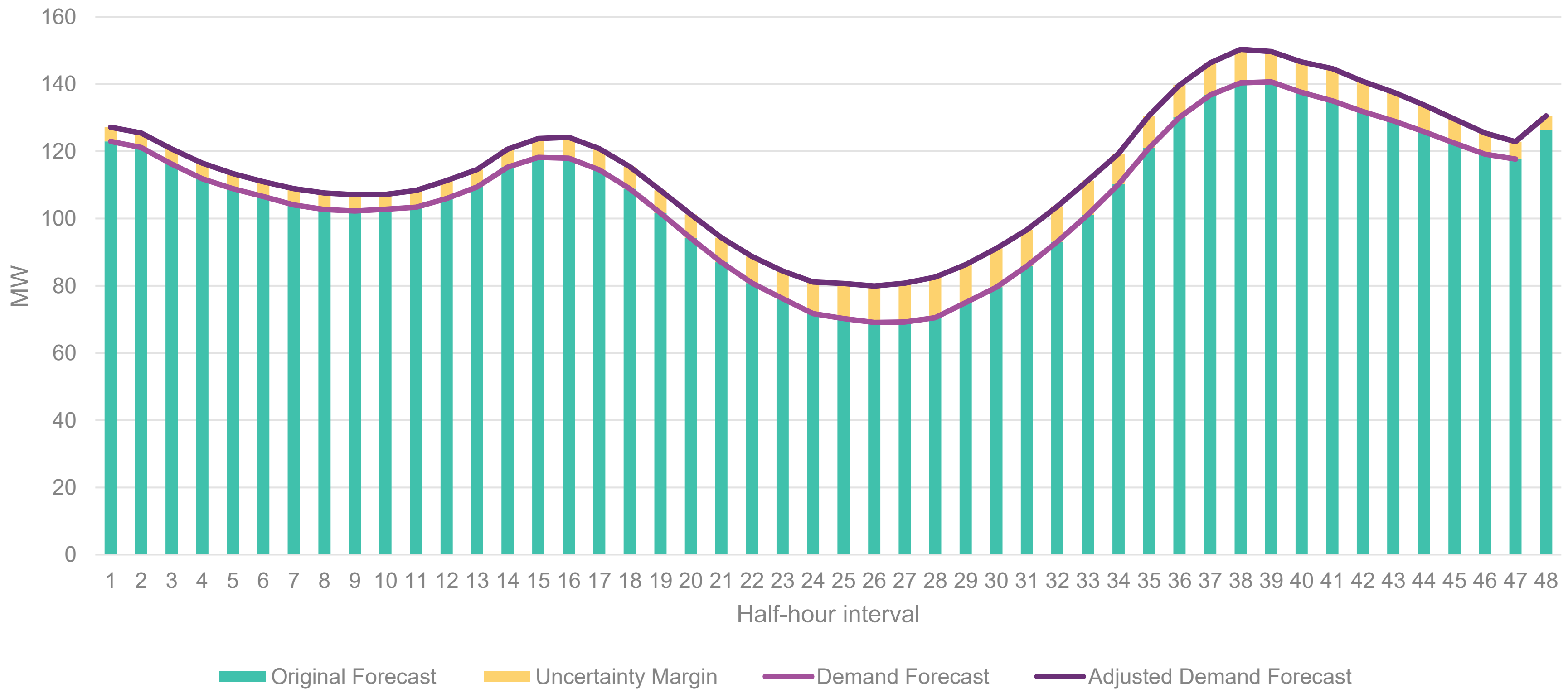
# Demand Methodology
## From Substation to Node (Feeder)



# Operational Demand Uncertainty Adjustment

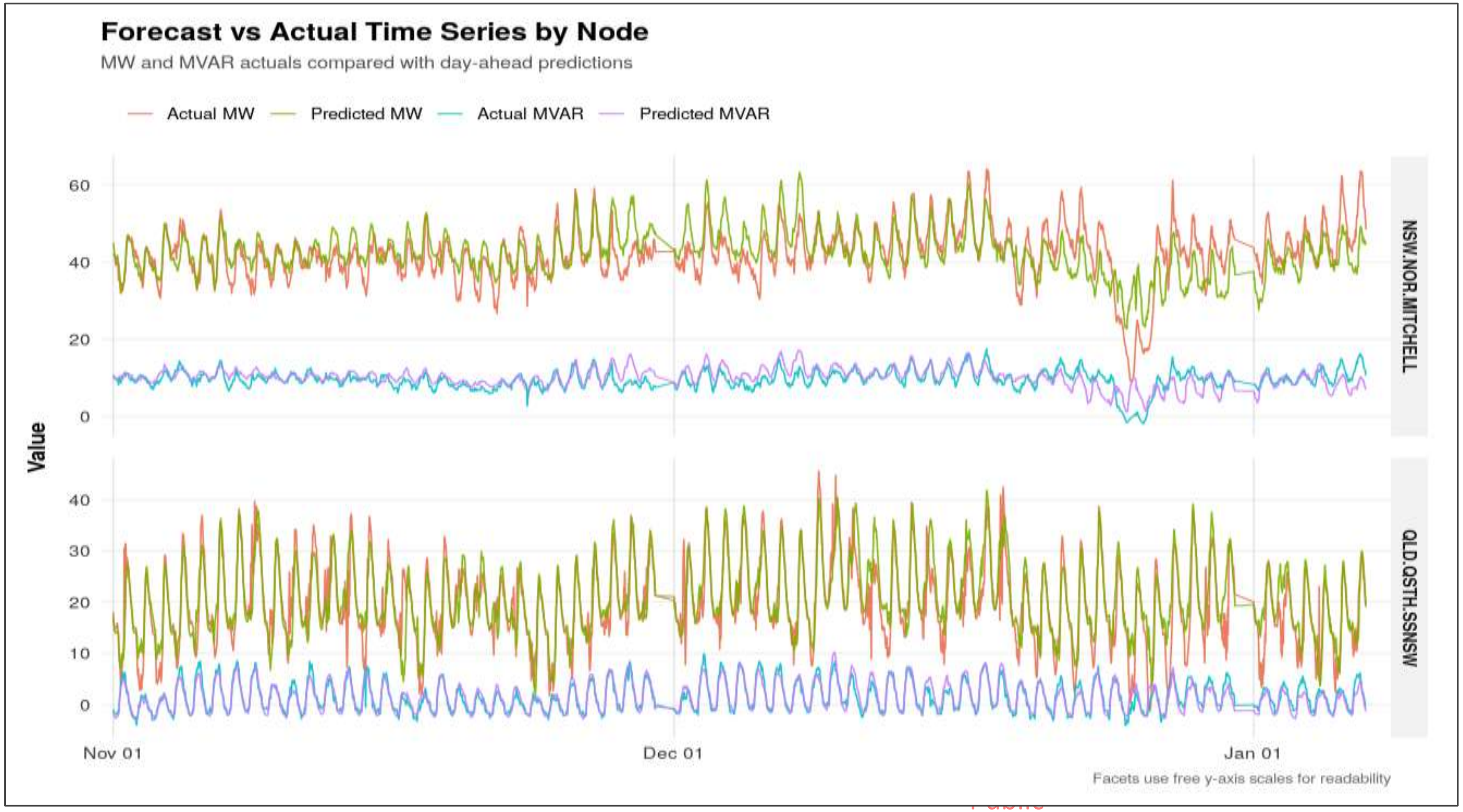
## Used just for Region Wide Operational Demand

- Adjust Operational Demand forecast by **adding** the Uncertainty Margin. (i.e. we increase expected demand)



# Challenges & Characteristics of Nodal Data

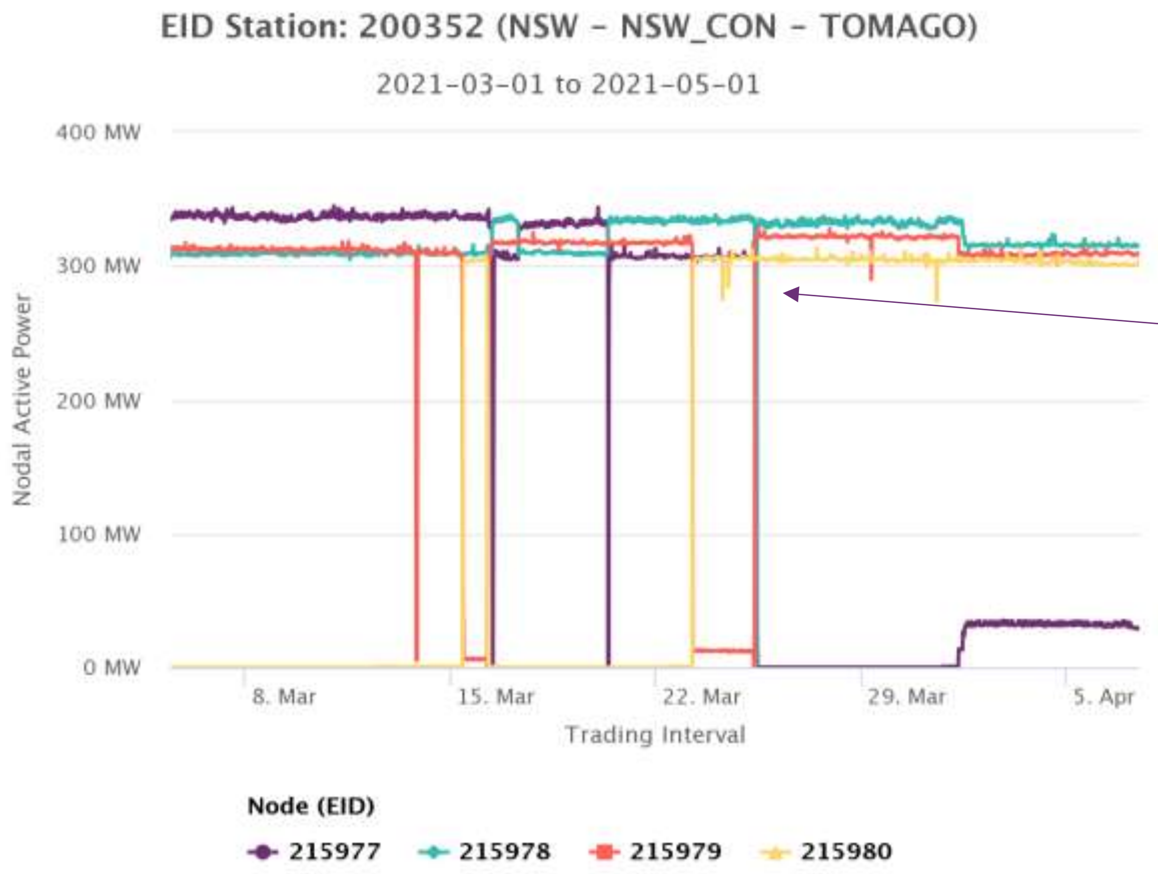
1. Node point (feeders) are inherently noisy. (i.e. their power demand profile are subject to rapid changes)
2. These changes can be caused by a variety of issues such as;
   i. Network Switching
   ii. Temperature Spikes
   iii. DER Equipment & Operating Behaviour
   iv. Industrial vs. Commercial vs. Residential Power Demand Profiles



Public

# Solutions for Nodal Forecasting

1. Aggregate the Feeders to the Substation (to de-noise the demand profile) and train models at the substation level
2. Created generalized features that work well across all substations. These features include;
   i. Multiple Weather Stations across the NEM
   ii. Lagged power demand from the substation were forecasting
   iii. Surrounding substations and their lagged power demand
3. Reduced ~1,700 nodes down to ~700 substation forecasts. (this simplified model managed and improved; model accuracy, training time, and inference runtime)

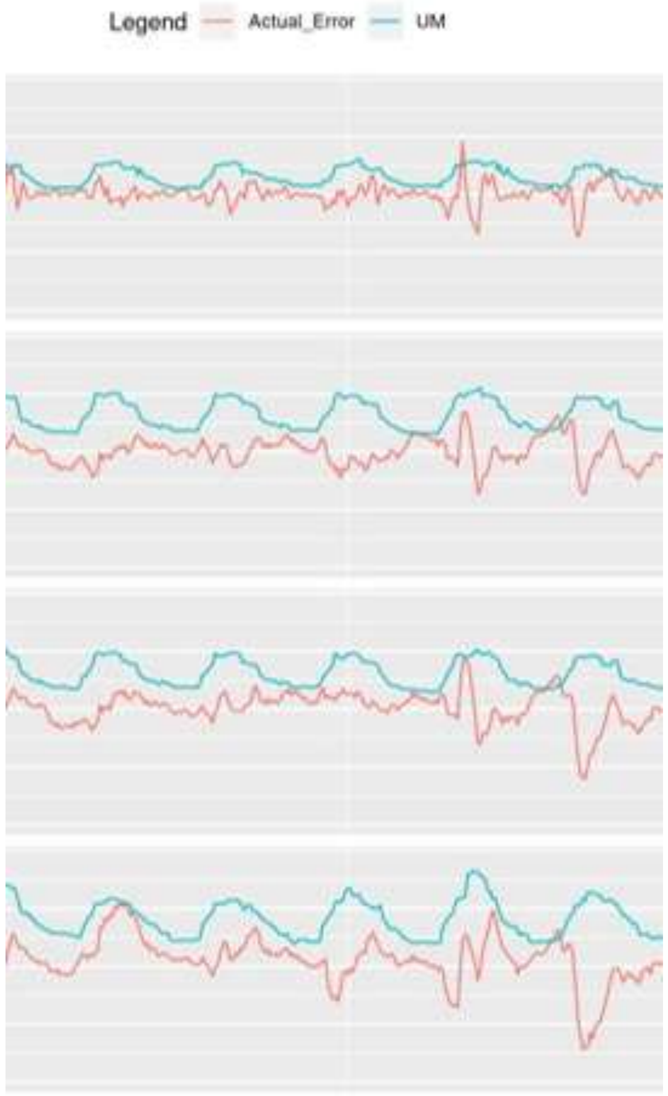



**Key Takeaways:**
Switching & Industrial Load Demand on the individual node is nearly impossible to predict

# Forecast Stack Validation

# Forecast Stack: Sense Checks and Validation

AEMO has undertaken a range of Forecast Stack validation activities to check that the models, uncertainty settings and output behaviour are directionally sensible




These include (but not limited to):

- **Model QA and reasonability checks**
Scored the Forecast Stack models and reviewed outputs both quantitatively and qualitatively to confirm they behave sensibly.
- **POE-level validation**
Checked whether uncertainty settings behave as intended, including whether high-POE forecasts sit on the conservative side of actual outcomes.
- **Method comparisons**
Tested alternative nodal forecasting approaches, including machine learning methods, neural-network-style approaches and rolling-average benchmarks.
- **End-to-end output readiness**
Checked that the Forecast Stack can produce the key PASA-ready demand and generation outputs required by the downstream PASA workflow.


Public

# Backcasting: Goals and Objectives

Backcasting is a controlled historical replay of the new ST PASA workflow. It allows us to test how the integrated system would have behaved under past operating conditions and provides a broader system-wide check beyond just the Forecast Stack alone.

**The main goals of Backcasting are:**

### Test Complete System Integration

- Confirm that all technical "piping", including applications, environments, services and processes, are fully integrated and cor... cor...

### Confirm Operational Viability

- Demonstrate that the system can successfully execute and resolve multiple PASA cases from start to finish.

### Validate System Performance

- Check that reserve and deficit outcomes are reasonable when compared with historical system conditions and known market notice events.

### Calibrate and tune settings

- Use backcasting to test different configurations & support selection of appropriate settings, incl Forecast Stack POE levels & PASA Engine/ process parameters.

# Initial Backcasting: Context & Scope

This initial phase deliberately focused on a small number of historical PD cases from October 2025 to provide an early indication of whether the forecasting and uncertainty approach behaves reasonably under the new PASA workflow (especially before broader and more comprehensive backcasting is undertaken).

| | |
|---|---|
| **Case selection** | • Two historical stress periods linked to market notices, plus one neutral control case where no market notice or LOR was declared. |
| **Uncertainty assessments** | • Each case was assessed under three uncertainty settings — ***baseline, moderate and near-maximum*** — to observe how outcomes changed as uncertainty allowances increased |

# Initial Backcasting – Case Selection

For this backcasting activity, we selected three historical PD-timeframe cases:

| Case Selected (PD Run Time) | Market Notice | Historical Declaration | What Happened | Why Case Selected |
|---|---|---|---|---|
| **2025-10-20 09:00** | Market Notice [MN] 129839 | LOR2 Declared in New South Wales | NSW reserve conditions tightened across the mid-day, evening peak and overnight period. The event was driven by increased demand, reduced generation availability and network outage impacts. Conditions later improved after increased generation availability and reduced demand, with network actions also taken to improve availability. | Selected as a historical NSW stress case, where reserve conditions were materially tight enough to produce forecast LOR2 conditions. |
| **2025-10-26 12:00** | No Market Notice Issued | No historical market notice / no LOR | No corresponding historical LOR declaration was identified for this selected runtime. It represents a period without an associated market notice signal. | Selected as a neutral comparison case, to provide a baseline period without a historical reserve-tightness signal. |
| **2025-10-27 06:30** | Market Notice [MN] 130047 | LOR1 Declared in Queensland | Queensland reserve conditions tightened primarily due to reduced generation availability. An earlier forecast LOR2 period was cancelled as conditions improved, while the later forecast LOR1 period was also cancelled after available generation increased and demand reduced slightly. | Selected as a Queensland stress case, providing a second LOR example in a different region and at a lower LOR level than the NSW case. |

# Initial Backcasting – Uncertainty Ranges

The uncertainty settings used in the initial phase were designed as a reasonability ladder rather than as a final operational recommendation. The three settings were:

## No Uncertainty

No Uncertainty Margin

**Baseline run.**

Expect no deficits.

Establishes a clean lower bound — the system with no uncertainty adjustment applied.

## 85% Uncertainty

Moderate Margin

**Below theoretical threshold.**

May influence outcomes subtly.

Provides a mid-point feel for how partial uncertainty adjustment shapes the solution.

## 99% Uncertainty

Near-Max Margin

**Near-maximum uncertainty.**

Expect to raise deficits in LOR market notices.

Demonstrates the system can surface real-world risks of energy shortfalls and supply deficits.

## Assessment Logic

By selecting cases with known LOR market notices, we expect:
No Uncertainty → no deficit | 99% → deficit comparable to the declared notice | 85% → below threshold.

And as we increase uncertainty, we expect more shortfalls to be triggered.

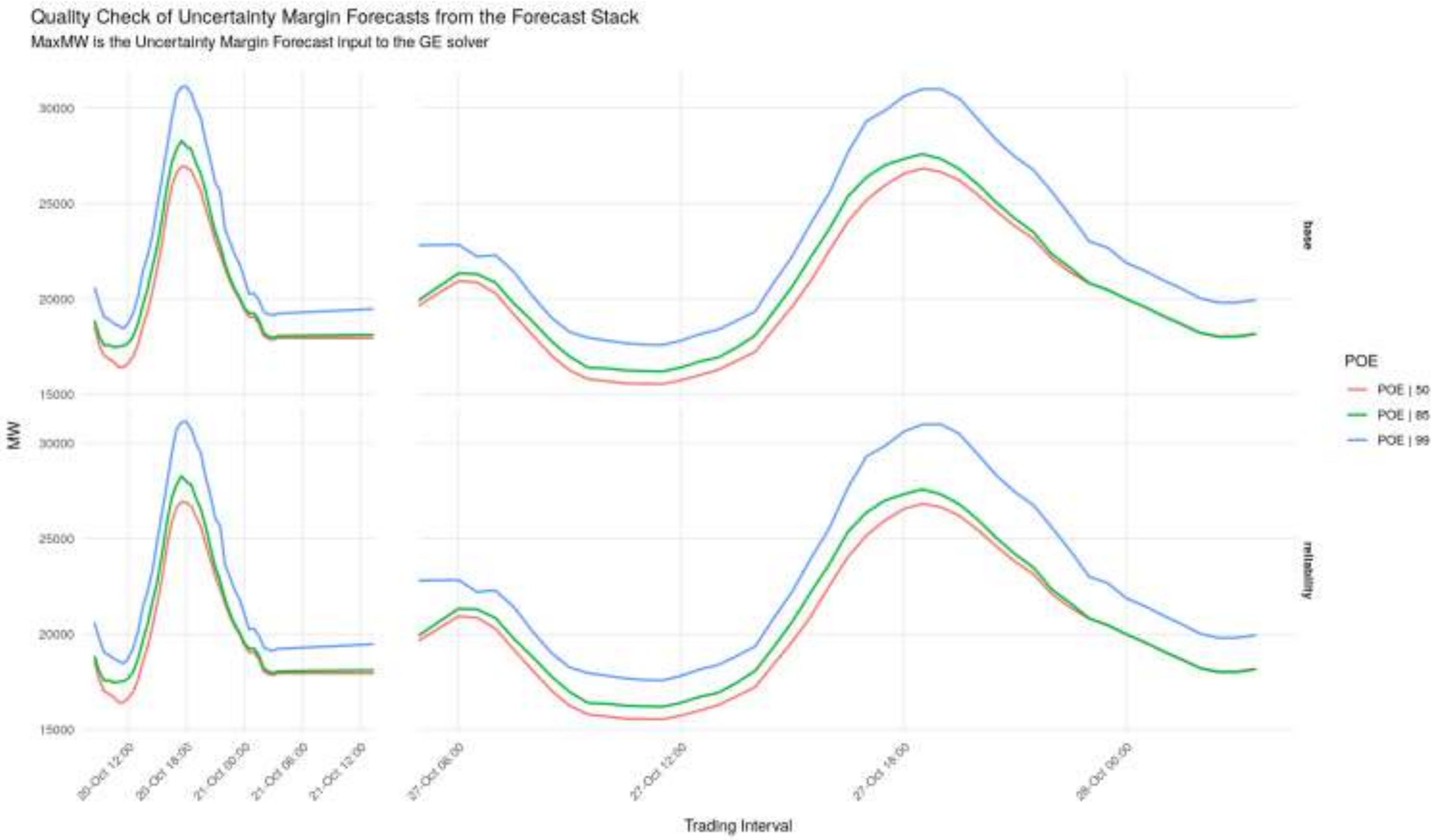
If results follow this pattern, it indicates the new PASA system can surface energy-shortfall risk in proportion to uncertainty, with market notices acting as a practical reference point for what conditions looked like at the time.

Collectively, this approach will give us a meaningful feel for how the new system behaves ahead of our release.

# Initial Backcasting Results

# Initial Backcasting – Results and Insights

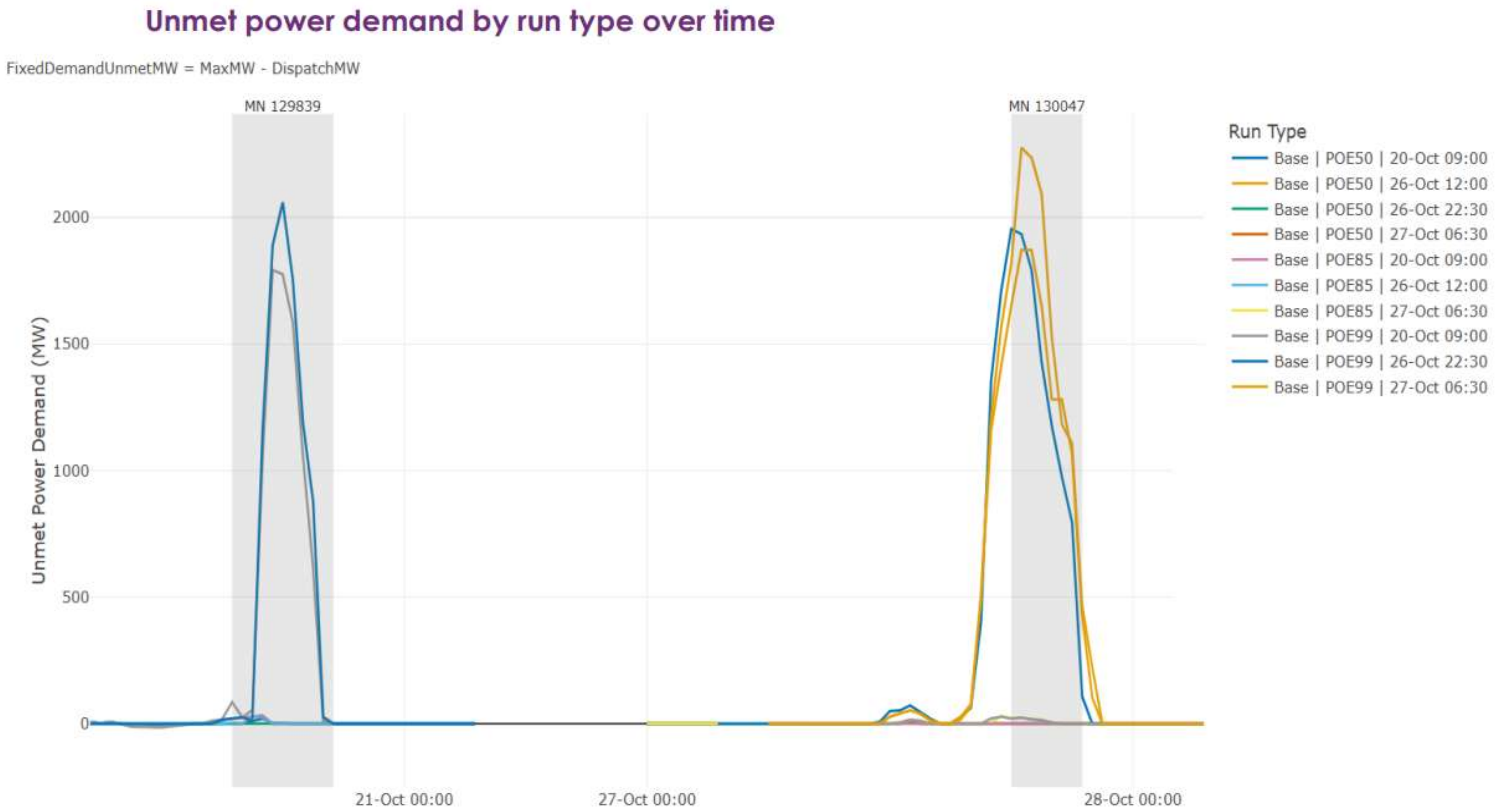
The first important early result is that the end-to-end process ran successfully, and that the Forecast Stack is producing reasonable Uncertainty Margin Forecasts across POE levels (indicating that the uncertainty settings are flowing through into the PASA engine as expected)




**Key Takeaway #1**
*QA check showing uncertainty margins behave as expected across POE levels (POE99 > POE85 > POE50).*

*It also highlights that POE85 sits much closer to POE50 than POE99, indicating further work is needed to determine the most appropriate uncertainty setting.*

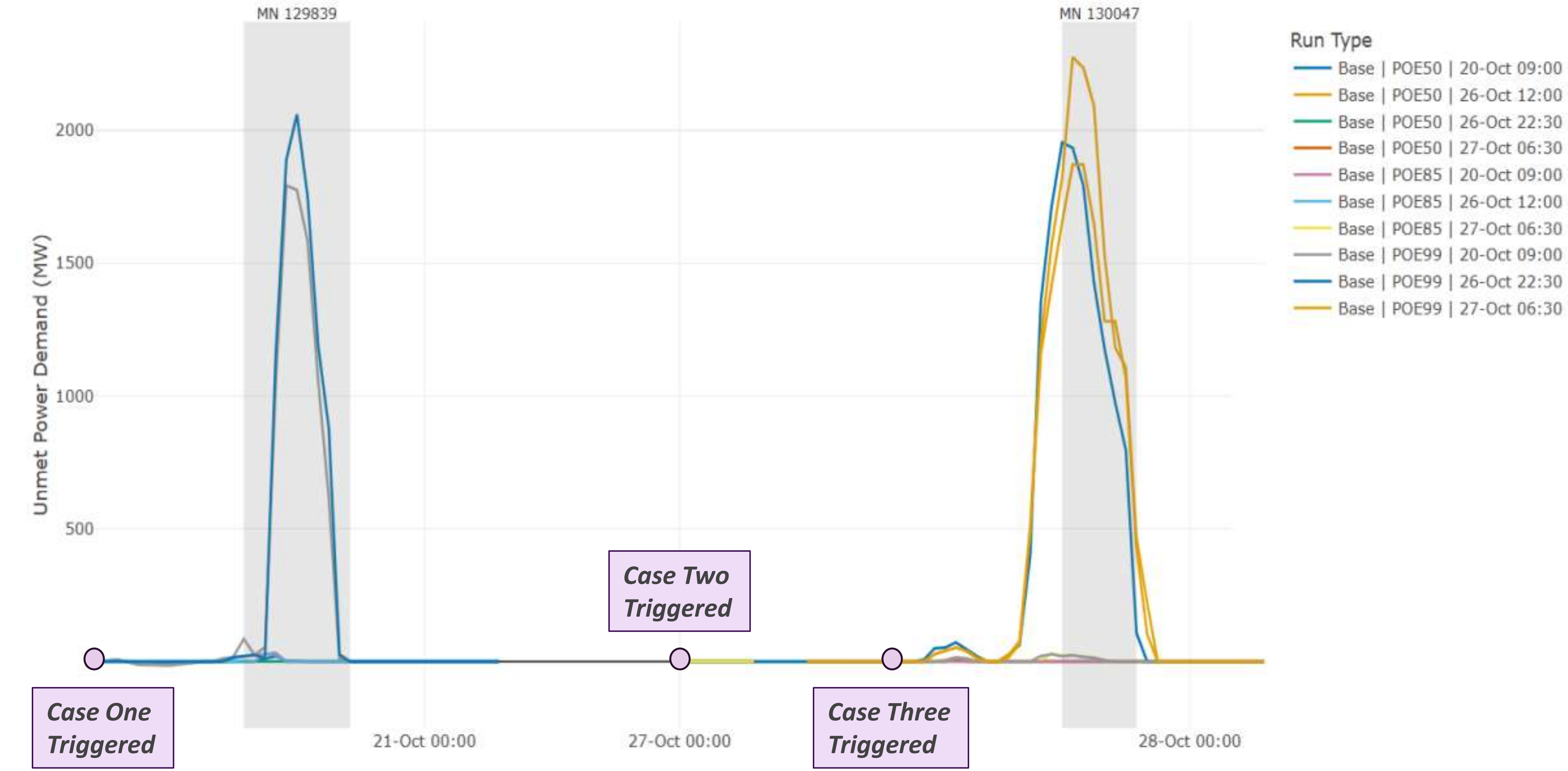
# Initial Backcasting – Results and Insights



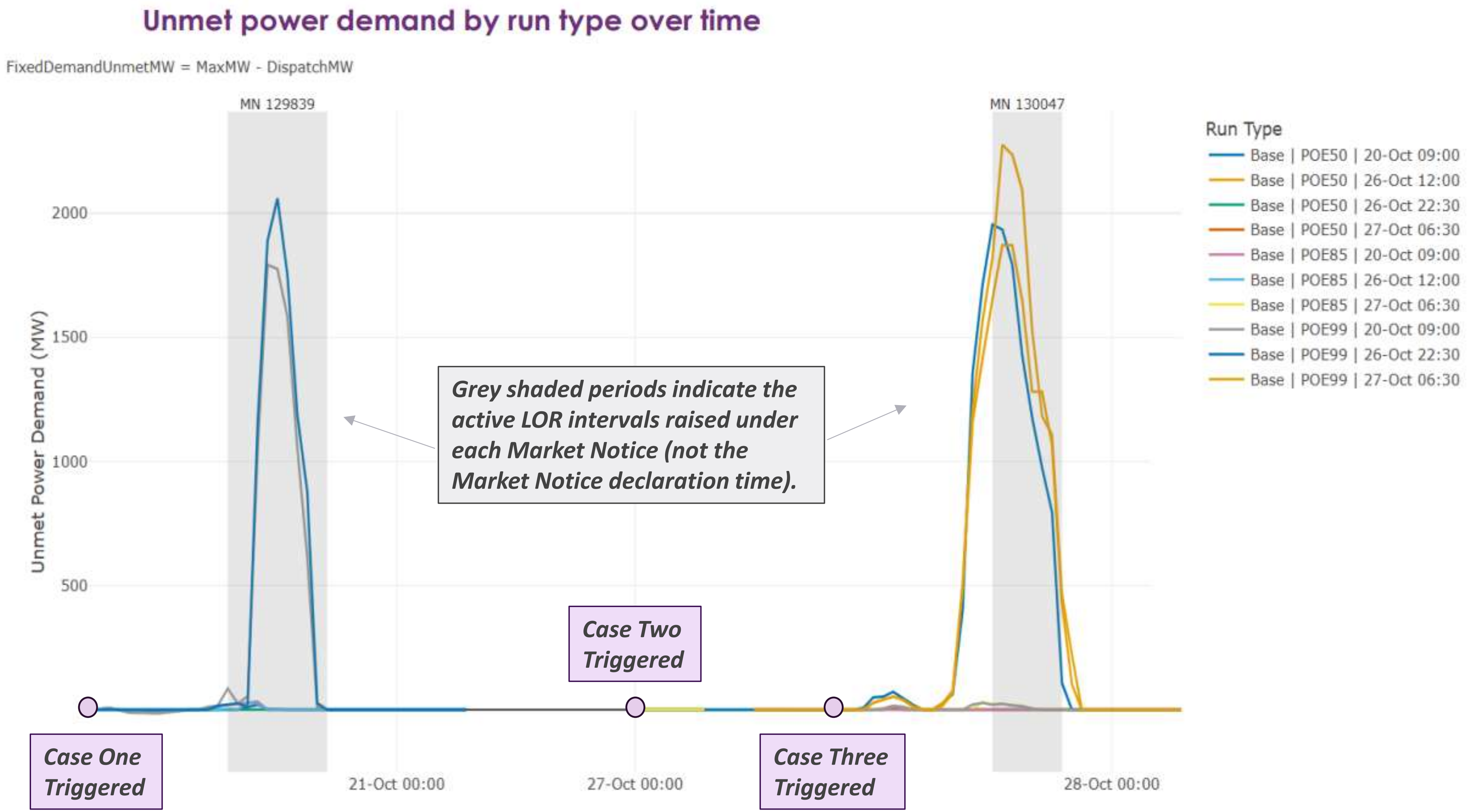
# Initial Backcasting – Results and Insights

## Unmet power demand by run type over time

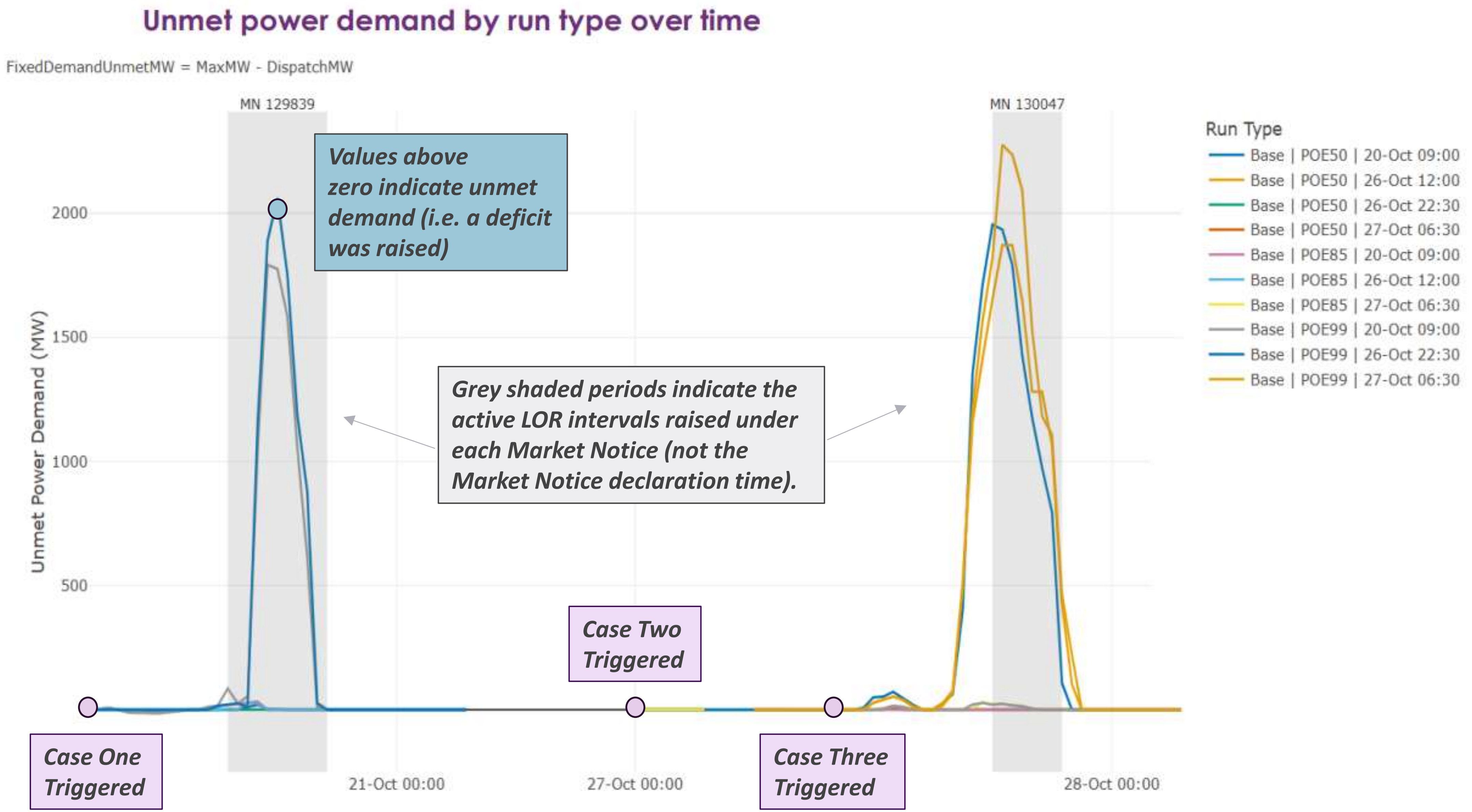
FixedDemandUnmetMW = MaxMW - DispatchMW



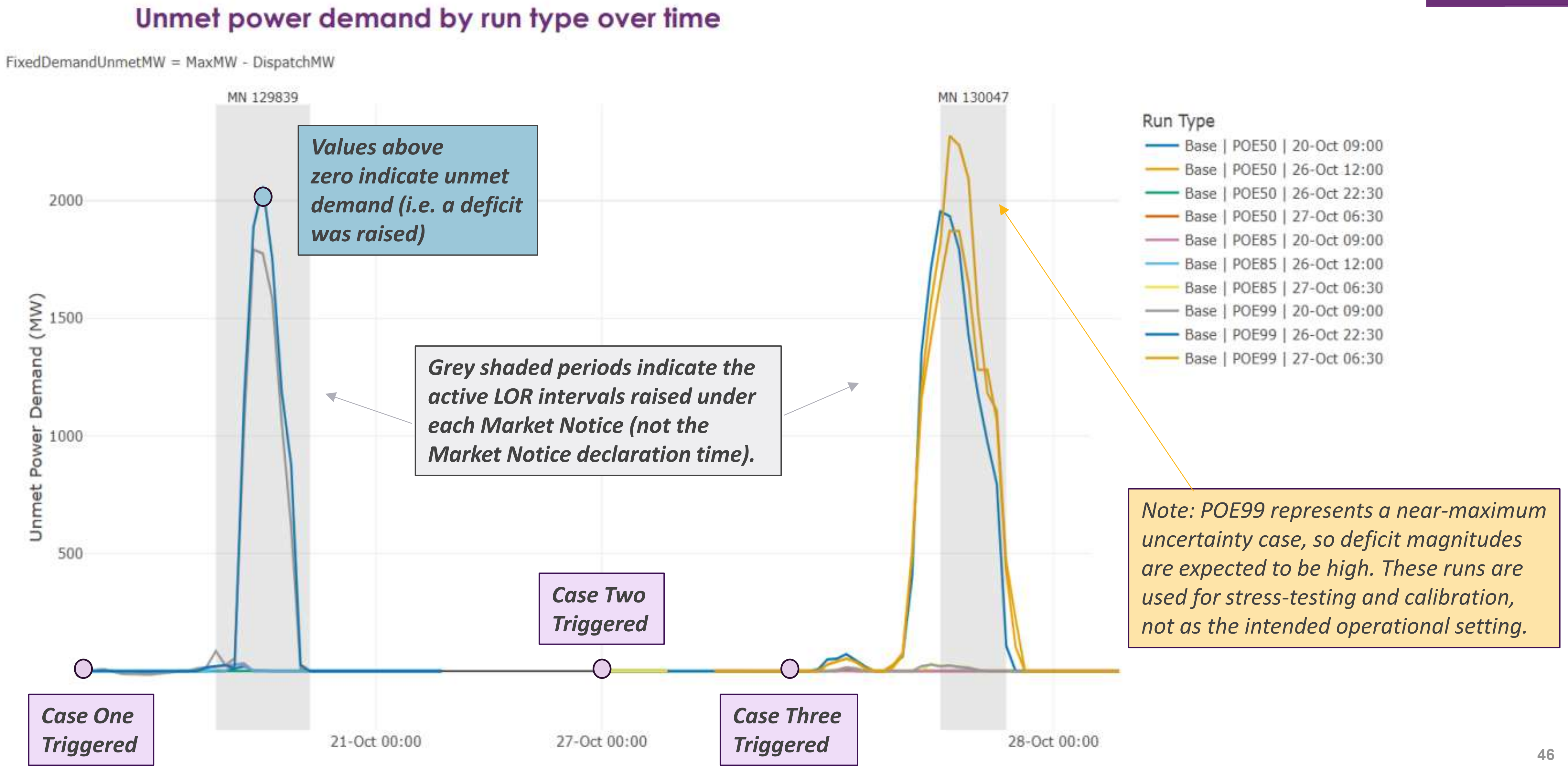
# Initial Backcasting – Results and Insights



# Initial Backcasting – Results and Insights



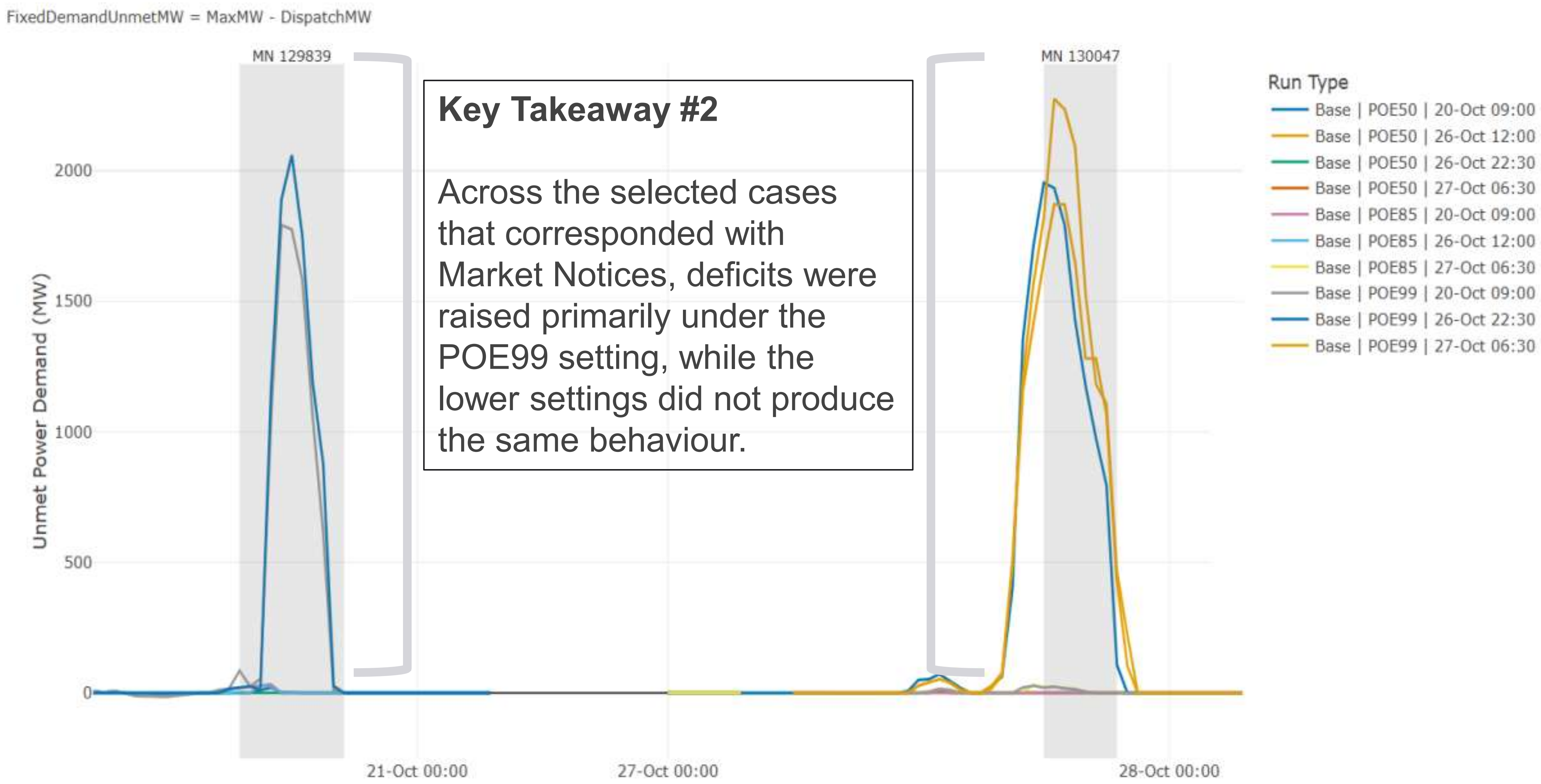
# Initial Backcasting – Results and Insights




*Note: POE99 represents a near-maximum uncertainty case, so deficit magnitudes are expected to be high. These runs are used for stress-testing and calibration, not as the intended operational setting.*

# Initial Backcasting – Results and Insights

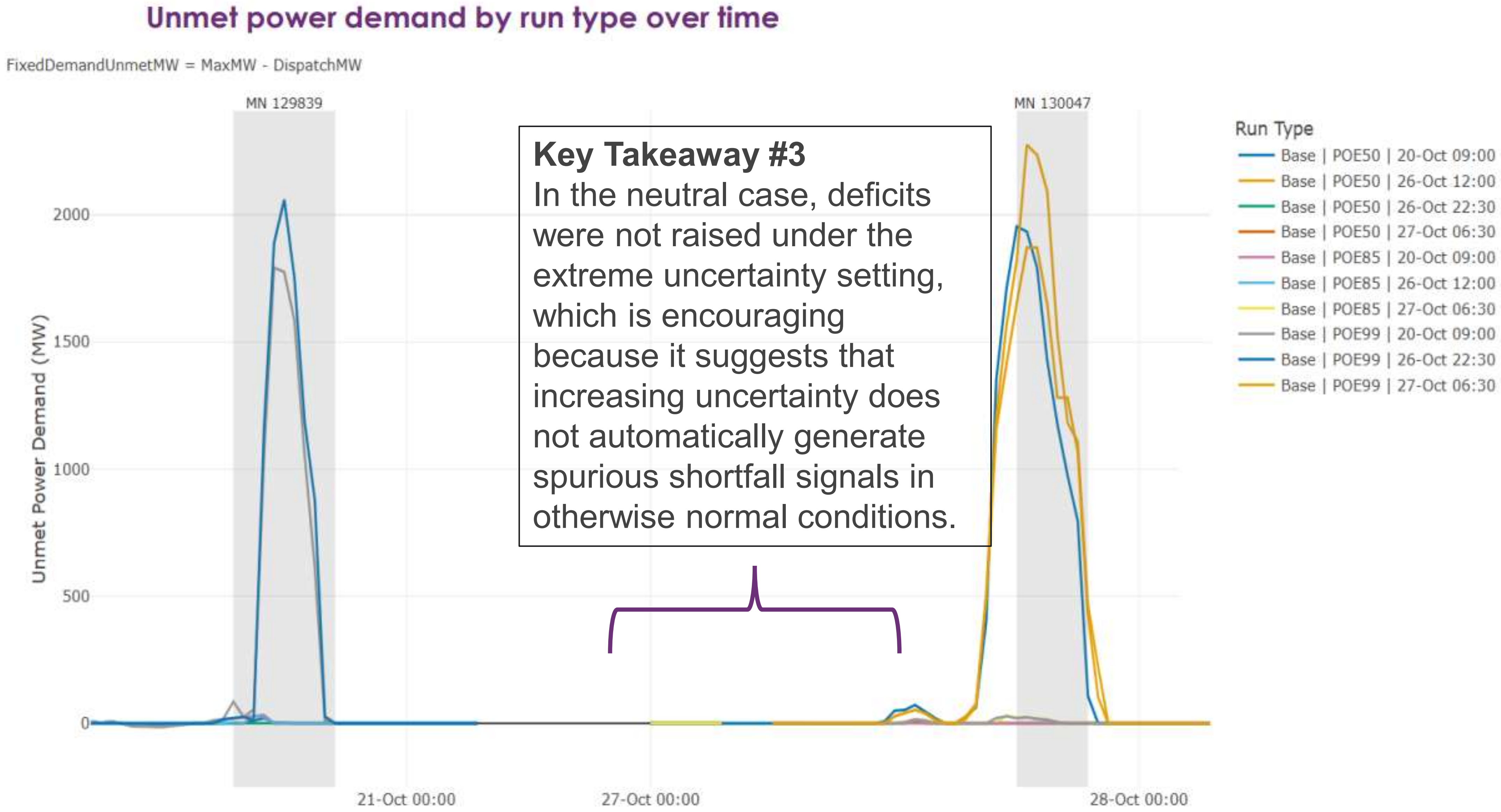
## Unmet power demand by run type over time




**Key Takeaway #2**

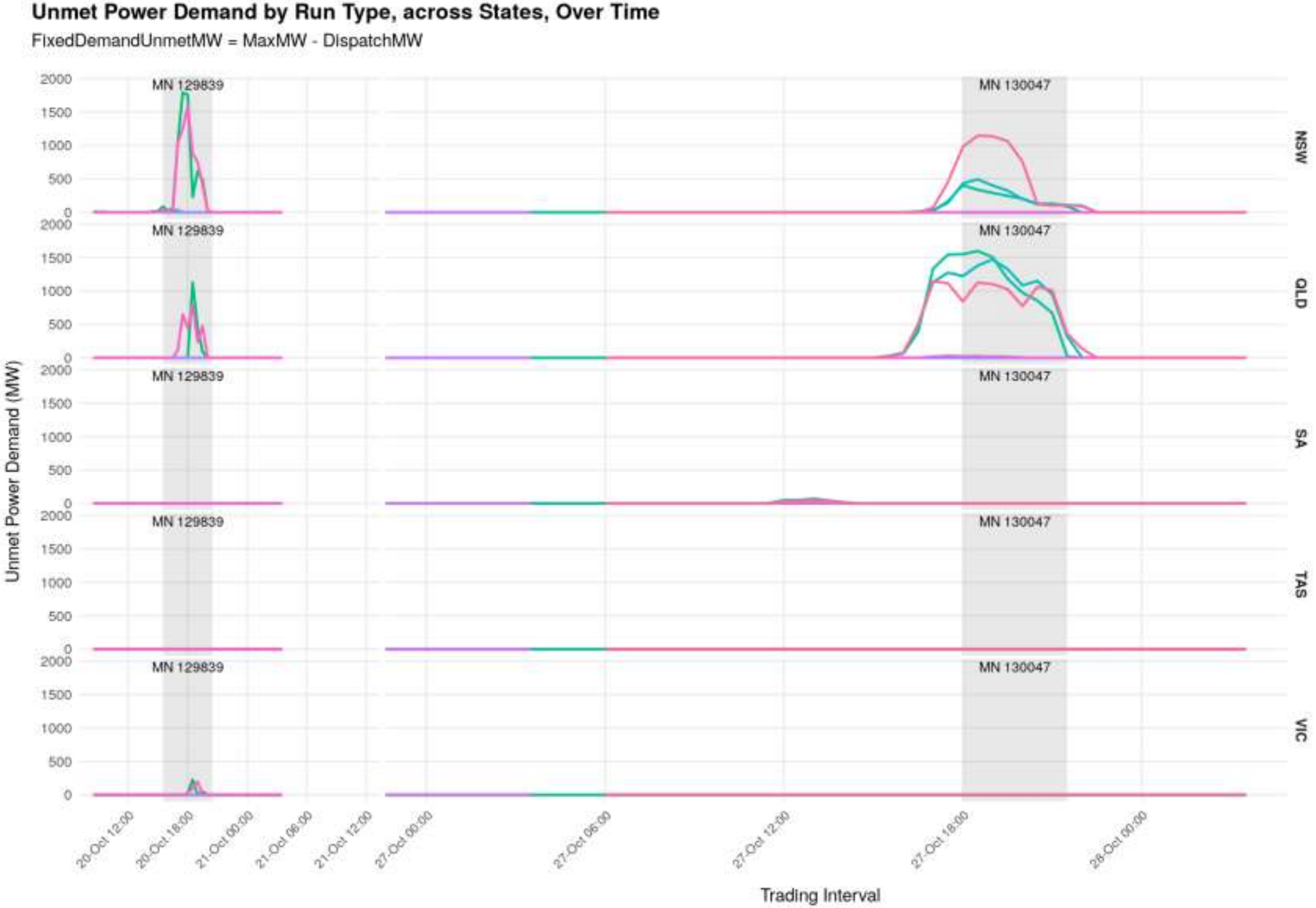
Across the selected cases that corresponded with Market Notices, deficits were raised primarily under the POE99 setting, while the lower settings did not produce the same behaviour.

# Initial Backcasting – Results and Insights




**Key Takeaway #3**
In the neutral case, deficits were not raised under the extreme uncertainty setting, which is encouraging because it suggests that increasing uncertainty does not automatically generate spurious shortfall signals in otherwise normal conditions.

# Initial Backcasting – Results and Insights




**Key Takeaway #4**
Under POE99 levels, unmet power was detected in both NSW and QLD for each case, even though the expected shortfall signal was NSW-only in Case 1 and QLD-only in Case 3.

This suggests the POE99 setting may be conservative enough to introduce some spillover into neighbouring regions.

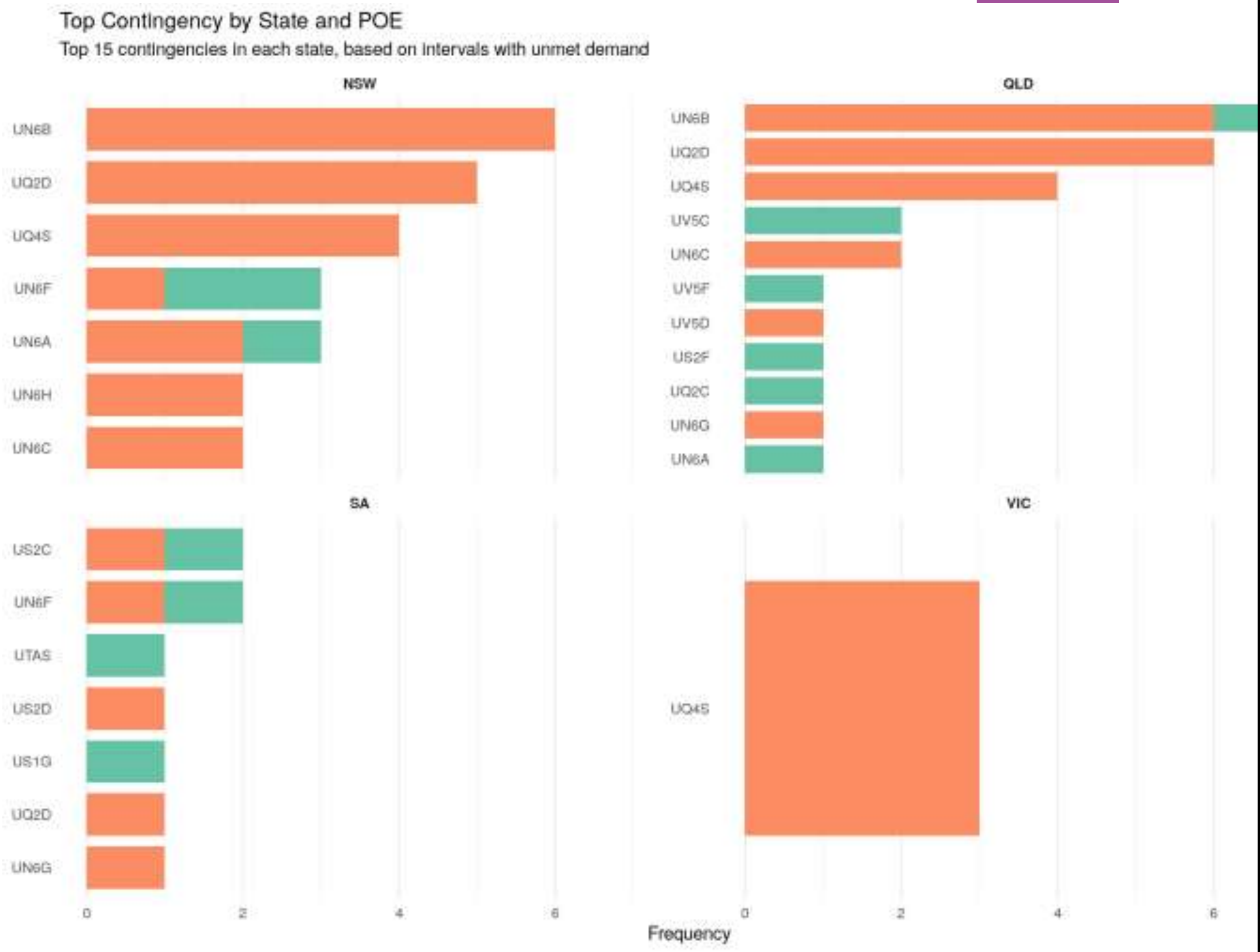
Importantly, however, the deficit magnitude remained higher in the expected state for each case (NSW > QLD in Case 1, and QLD > NSW in Case 3).

This indicates there should exist a balanced setting between POE85 and POE99 that would lower the unmet power outcomes to both preserve the expected state-level signal and reduce spillover into adjacent regions

# New Capabilities Unlocked

The new system shifts PASA outcome assessment from broad reserve signals toward more targeted, explainable, and network-aware reliability insights.

- **Node-level deficit visibility**
  Deficits can be assessed at individual nodes, rather than only through broader regional reserve signals.
- **Targeted investigation of problem areas**
  Results can be reviewed by node, zone and region, helping identify whether projected deficits are localised or system-wide.
- **Scenario and contingency assessment**
  Different network and contingency conditions can be assessed to understand how outcomes change under alternative assumptions.
- **More actionable PASA insights**
  Granular outputs support more focused interpretation of PASA results and help inform better decision making.



# Backcasting: Key Insights

## Workflow

End-to-end workflow is now operating (that includes the Forecast Stack, PASA Engine and other supporting processes)

## POE Impact

In the initial case set examined, shortfall signals were observed under the most conservative uncertainty setting (POE99) rather than under POE50 or POE85.

- This provides initial evidence that the choice of POE setting materially influences whether a shortfall signal is produced.

## Calibration

The initial results indicate that POE99 was sufficient to produce shortfall signals where historical stress conditions were present, while not producing a shortfall in the neutral control case.

- This suggests that conservative POE settings alone do not necessarily trigger shortfalls without underlying system stress.
- However, POE99 also produced some broader shortfall patterns in some runs (including spillover into adjacent regions), indicating that calibration is still required

# Backcasting: Next Steps

These results are encouraging, but they are based on a limited case set therefore more comprehensive backcasting is required.

This will include:

- Assessment of reserve margins against various PoE levels
- Significantly more historical market notices and neutral periods, across seasons, regions and days of interest
- Determination of whether Reliability Standards can be reasonably met
- Exploration of how deficits evolve over time and location

Public

# 4. Delivery roadmap and key dates

Brian Nelson – AEMO

# Delivery roadmap and key dates

## Data model

- Participant data model implemented in pre-production earlier this year, but no data being published

## Consultation

- Draft report submissions due 21 May 2026
- Final report due 17 July 2026

## Industry testing & parallel run

- Industry testing being planned
- Parallel run period – to be confirmed

## Implementation

- Transition and engagement plan being developed
- Commencement to be confirmed

# Questions

# Workshop Close

AEMO

AUSTRALIAN ENERGY MARKET OPERATOR

For more information visit

**aemo.com.au**

AEMO

# Appendix A

AEMO Competition Law - Meeting Protocol

# AEMO Competition Law

## Meeting Protocol

- AEMO is committed to complying with all applicable laws, including the Competition and Consumer Act 2010 (CCA). In any dealings with AEMO, all participants agree to adhere to the CCA at all times and to comply with appropriate protocols where required to do so.
- AEMO has developed meeting protocols to support compliance with the CCA in working groups and other forums with energy stakeholders. Before attending, participants should confirm the application of the appropriate meeting protocol.
- Please visit: https://aemo.com.au/en/consultations/industry-forums-and-working-groups