Variability and Uncertainty

An overview of the RIS Technical Appendix C

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Renewable Integration Study 101

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Variability and Uncertainty

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AEMO AUSTRALIAN ENERGY MARKET OPERATOR

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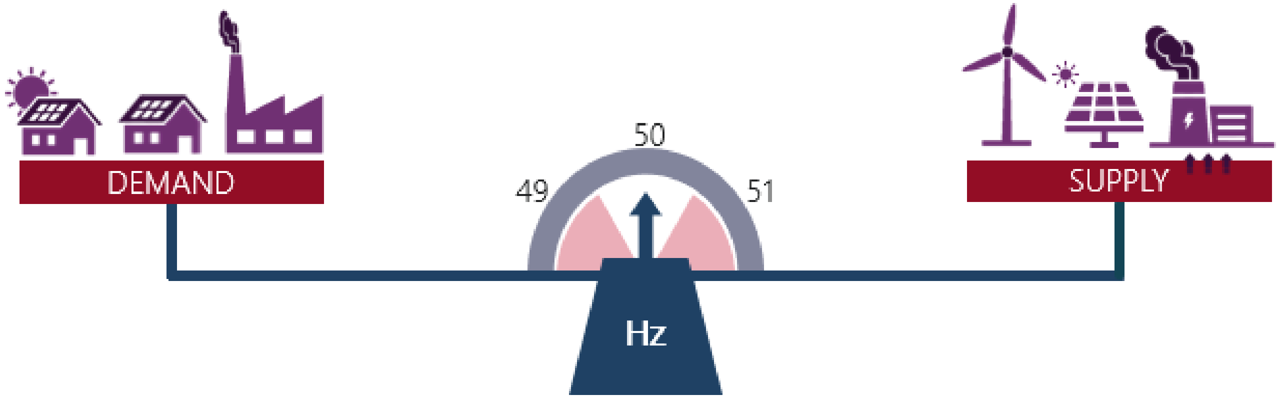
Today's Webinar

- Key concepts
- Approach
- Core areas of analysis
- Going forward

Key Concepts

The supply-demand balance

- Supply and demand are **balanced continuously and instantaneously**
- **Not readily storable**, although there is some pumped hydro and battery storage in the NEM
- The **NEM operates at 50 Hz**
- Deviating too far can cause **disconnection** and damage to equipment

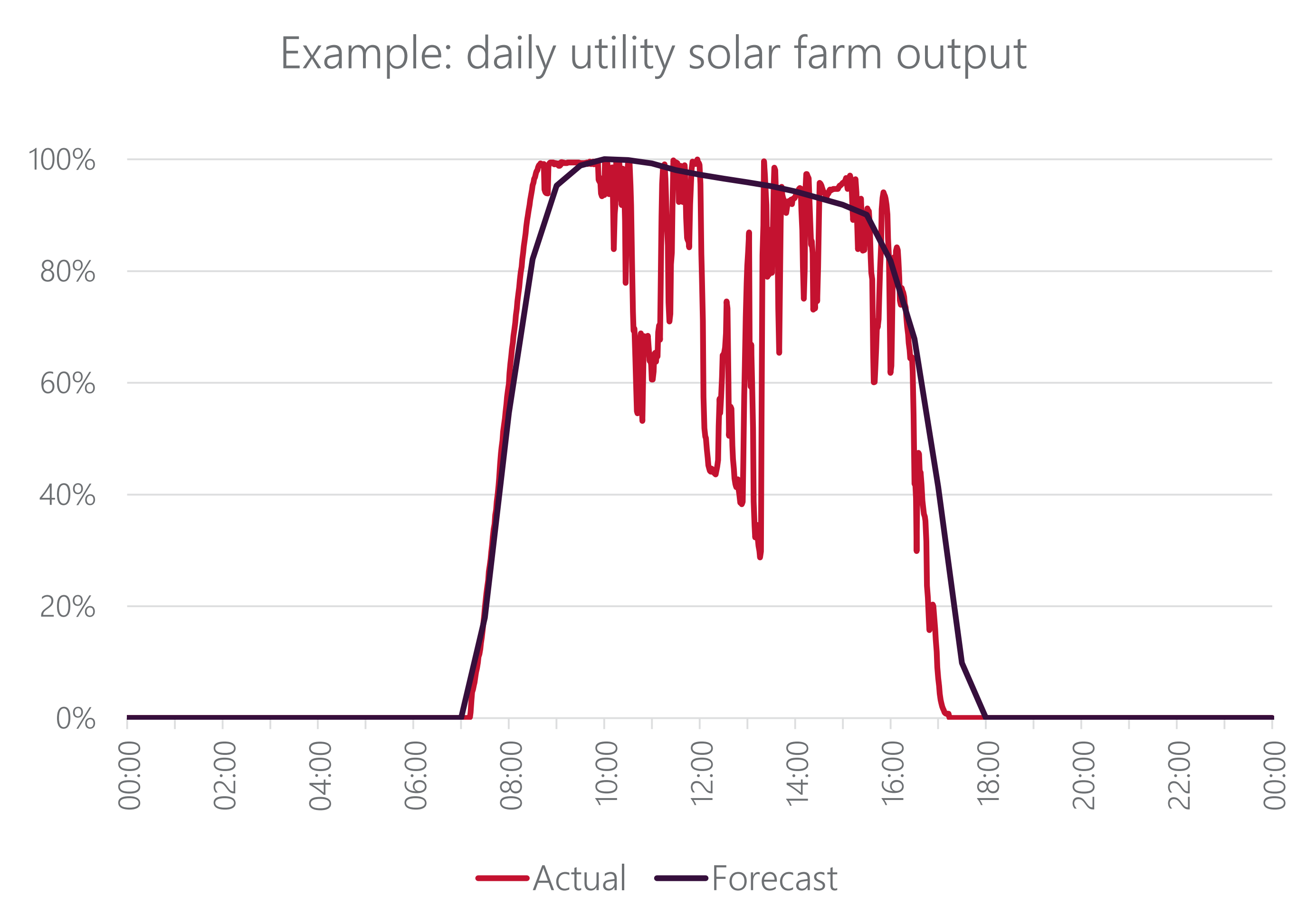


What is variability and uncertainty

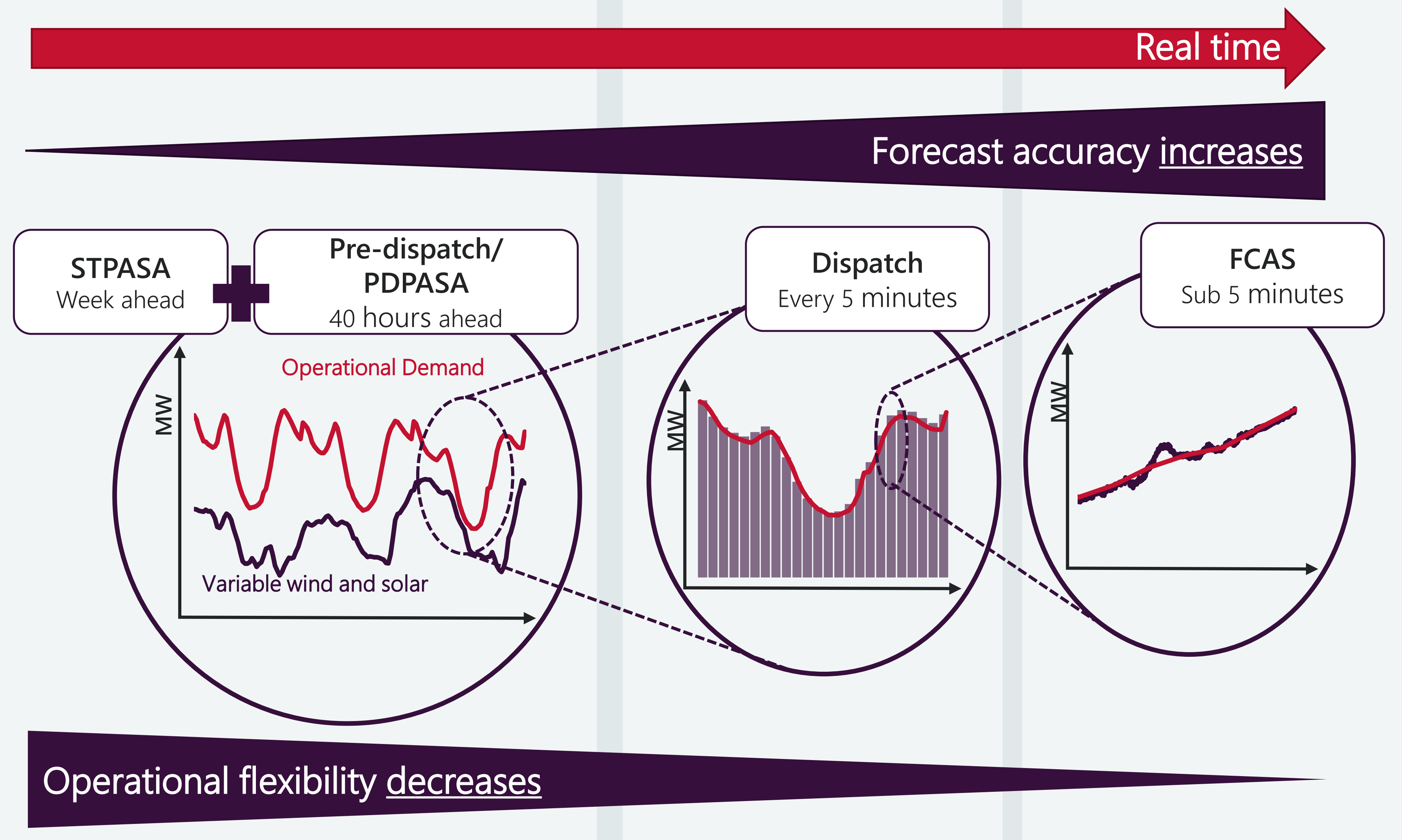
Variability relates to changes in supply and demand that would exist even with perfect foresight

Uncertainty relates to the inability to perfectly predict future demand, supply, and grid conditions

Variability and uncertainty **exist in all power systems**, regardless of wind and solar penetration



How balancing occurs in operational timeframes

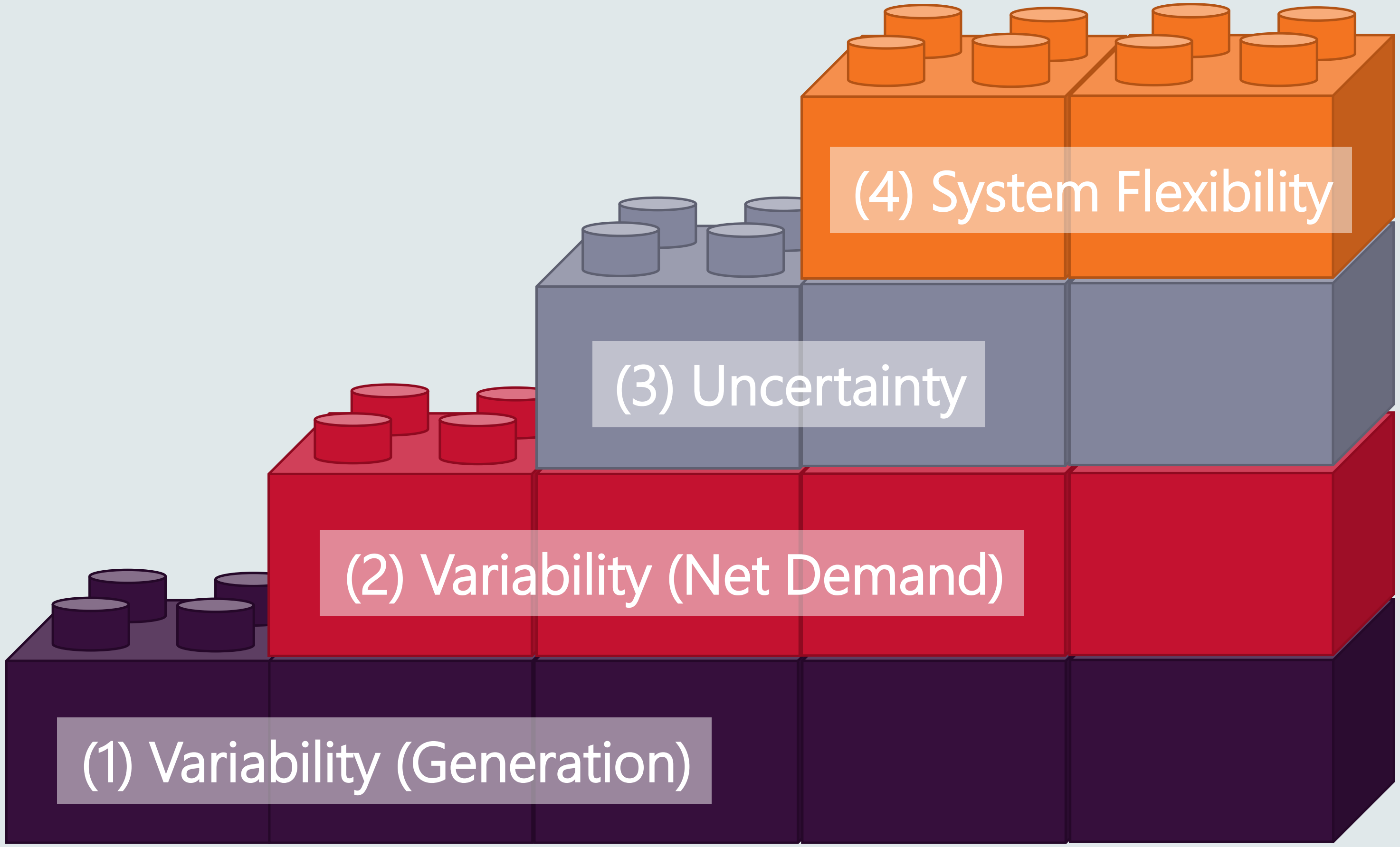


- Balancing occurs over many timeframes
- Different units have **different flexible characteristics**
- **Getting the right resource mix is important!**

System flexibility is the capability of the system to respond to **expected and unexpected changes** in net demand over **all necessary timeframes**

Approach

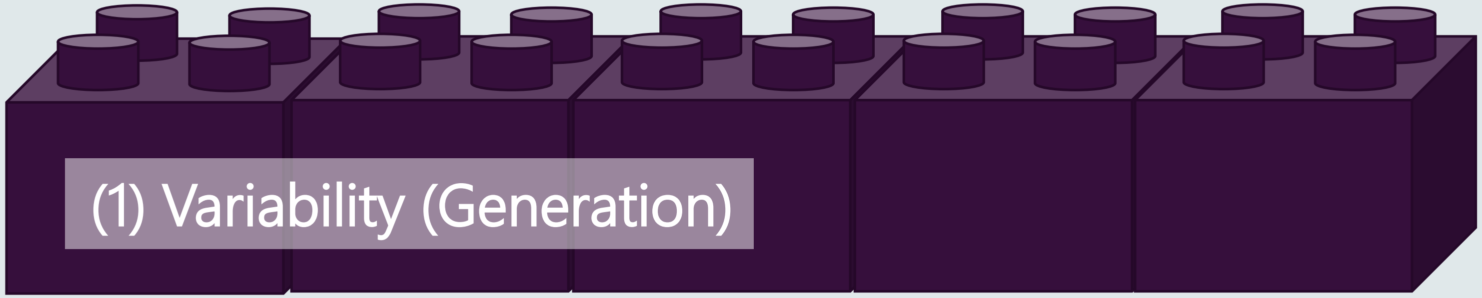
Approach



- Data analysis piece
- Historical and synthetic data
- 4 sections – each subsequent piece building upon the previous to help interrogate the data from different angles

Core areas of analysis

Building block #1 – Generation Variability

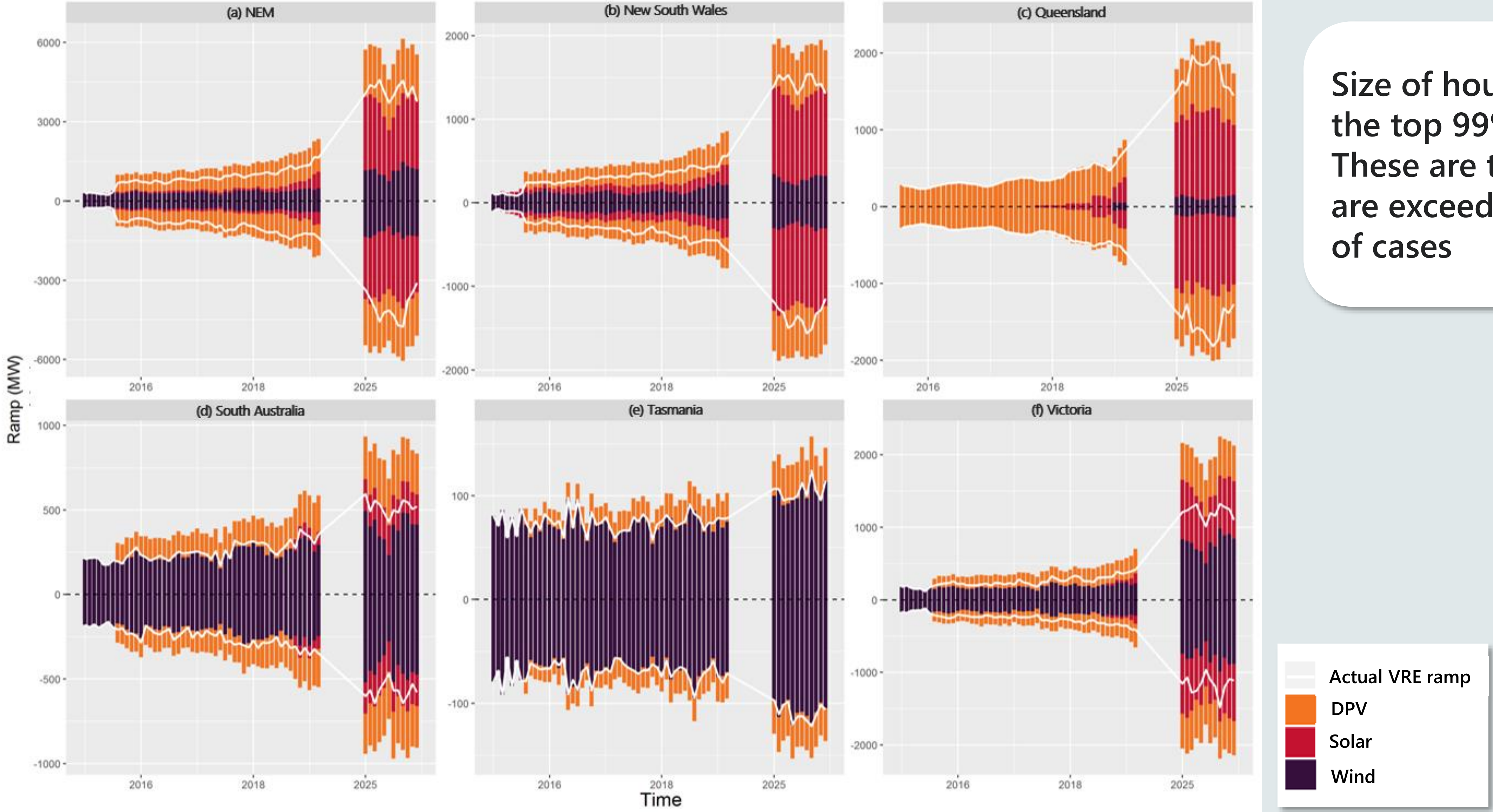


How much is variability from VRE (utility wind, utility solar, DPV) expected to change to 2025?

- Historical 2015 – 2019 and synthetic 2025 data
- 5-min resolution
- 500 million + data points
- 5-min, 1-hour, 4-hour overlapping ramp windows

For more information refer to Section C3.2 & C7.1

Increasing variability

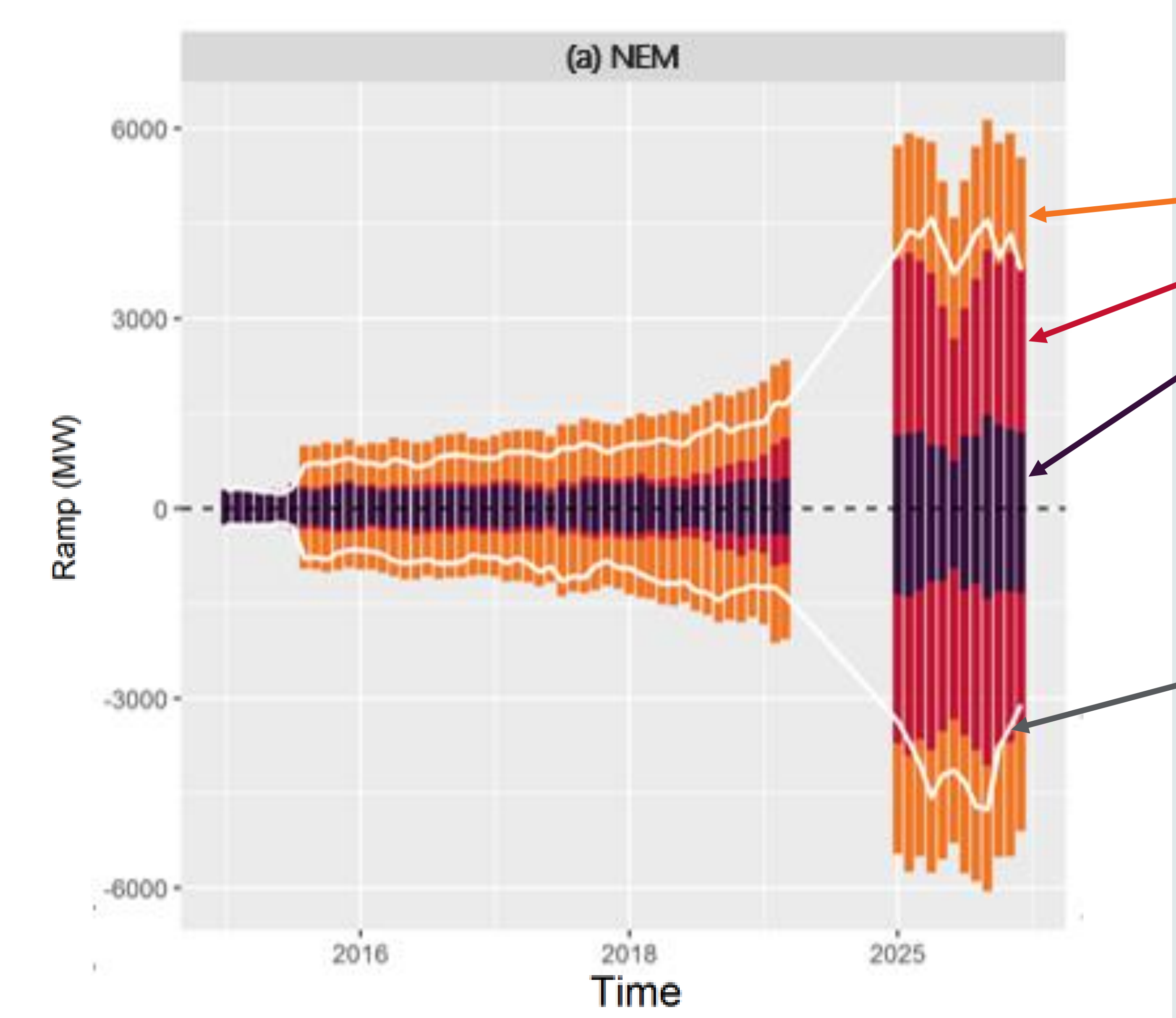


Size of hourly ramps in the top 99% by month. These are the values that are exceeded in only 1% of cases

For more information refer to Section C3.2

Increasing variability

Size of hourly ramps in the top 99% by month. These are the values that are exceeded in only 1% of cases



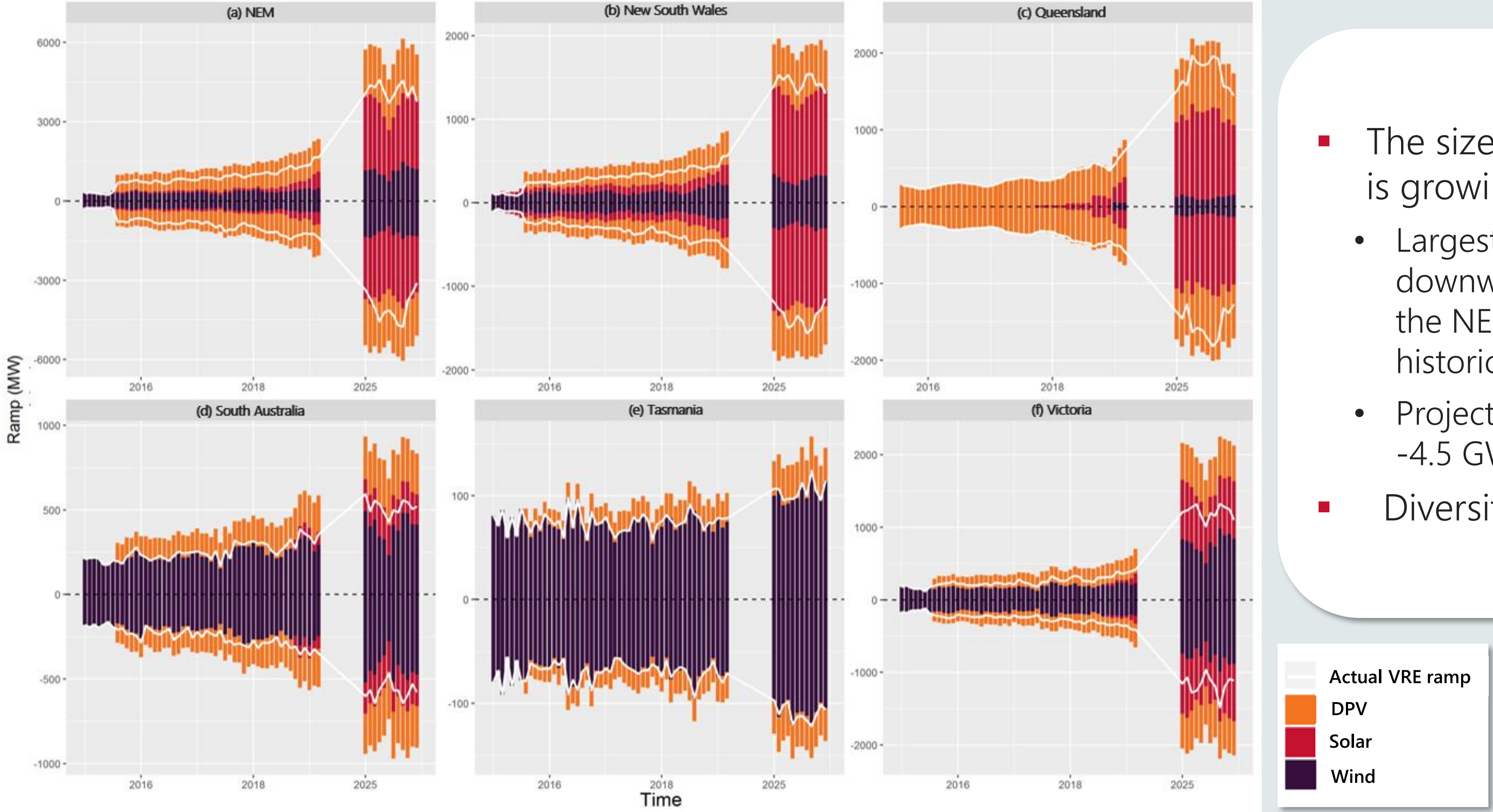
Coloured bars: monthly 99th percentile upward and downward ramp in MW for wind, utility solar and DPV *individually*

White line: observed monthly 99th percentile upward and downward ramp in MW from the overall movement in wind, utility solar and DPV

This is what was *actually observed*

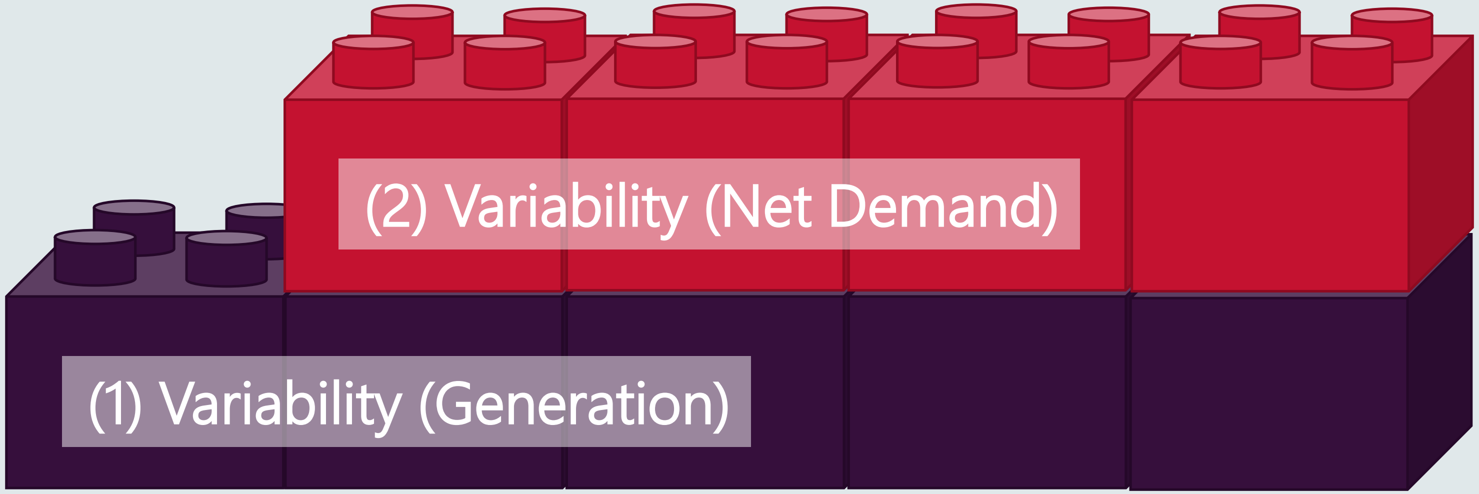
For more information refer to Section C3.2
For information on geographic diversity refer to Section C3.3

Increasing variability



- The size of VRE ramps is growing
  - Largest hourly 1% downward VRE ramp in the NEM was -1.4 GW, historically
  - Projected to reach -4.5 GW by 2025
- Diversity is important

Building block #2 – Net Demand Variability

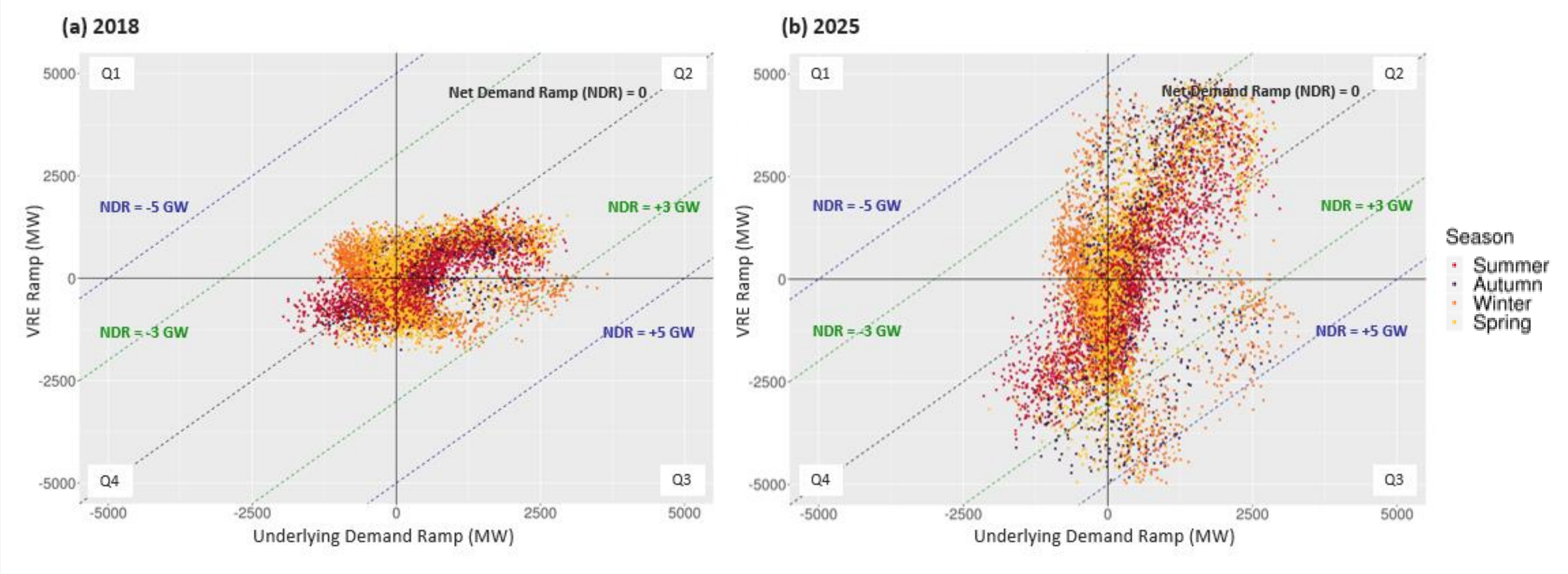


What is the residual variability that would need to be covered by the scheduled fleet in 2025?

- Incorporate variability from VRE and underlying demand
- 30-min resolution
- 1-hour, 4-hour overlapping ramp windows

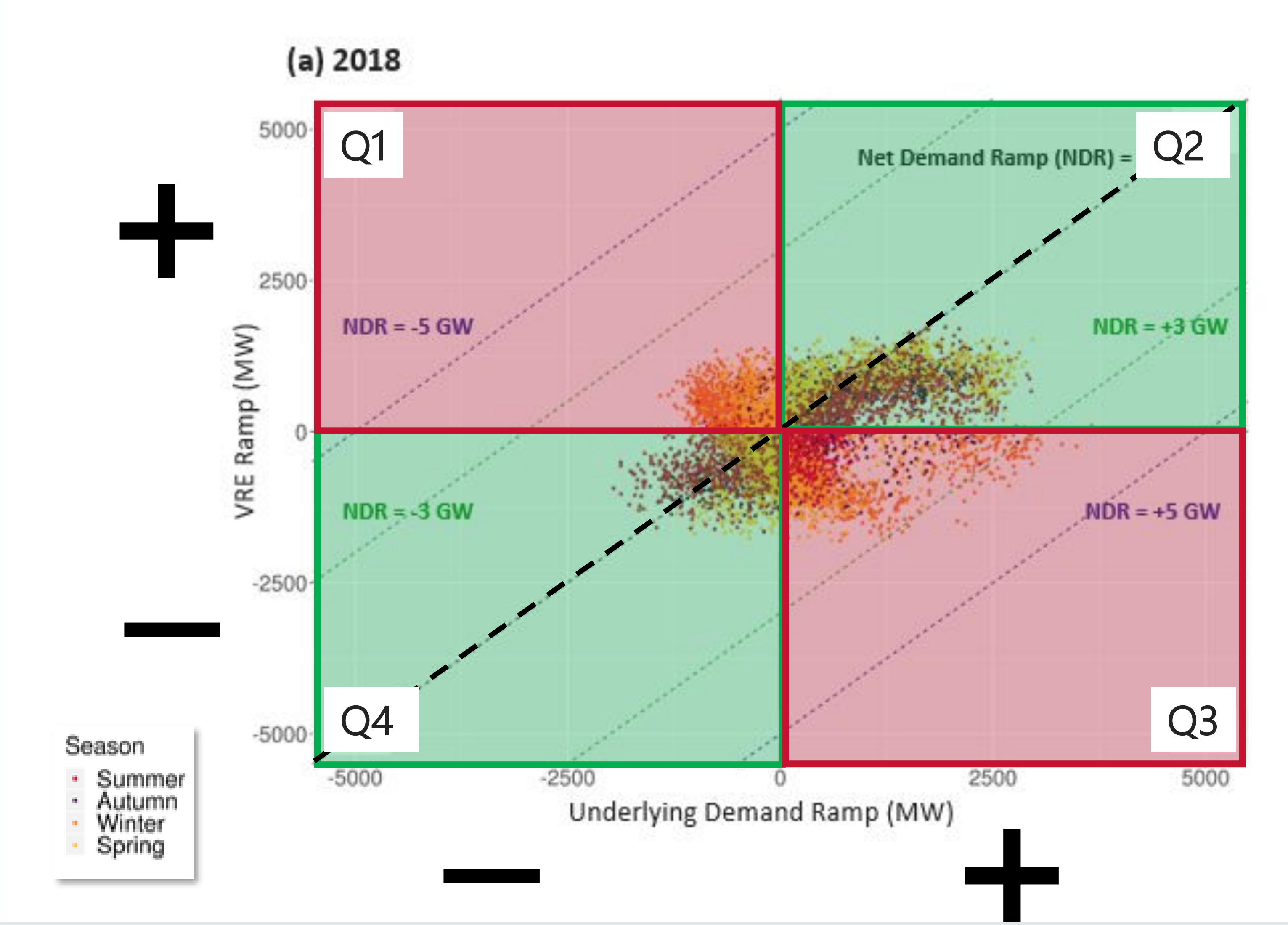
For more information refer to Section C3.4 & C7.1

Changes in net demand



- **1-hour ramps in VRE and underlying demand** – the combination of the two makes net demand
- Measured every 30-minutes for a year – 2018 and 2025
- Different colours indicate season

Interpreting net demand

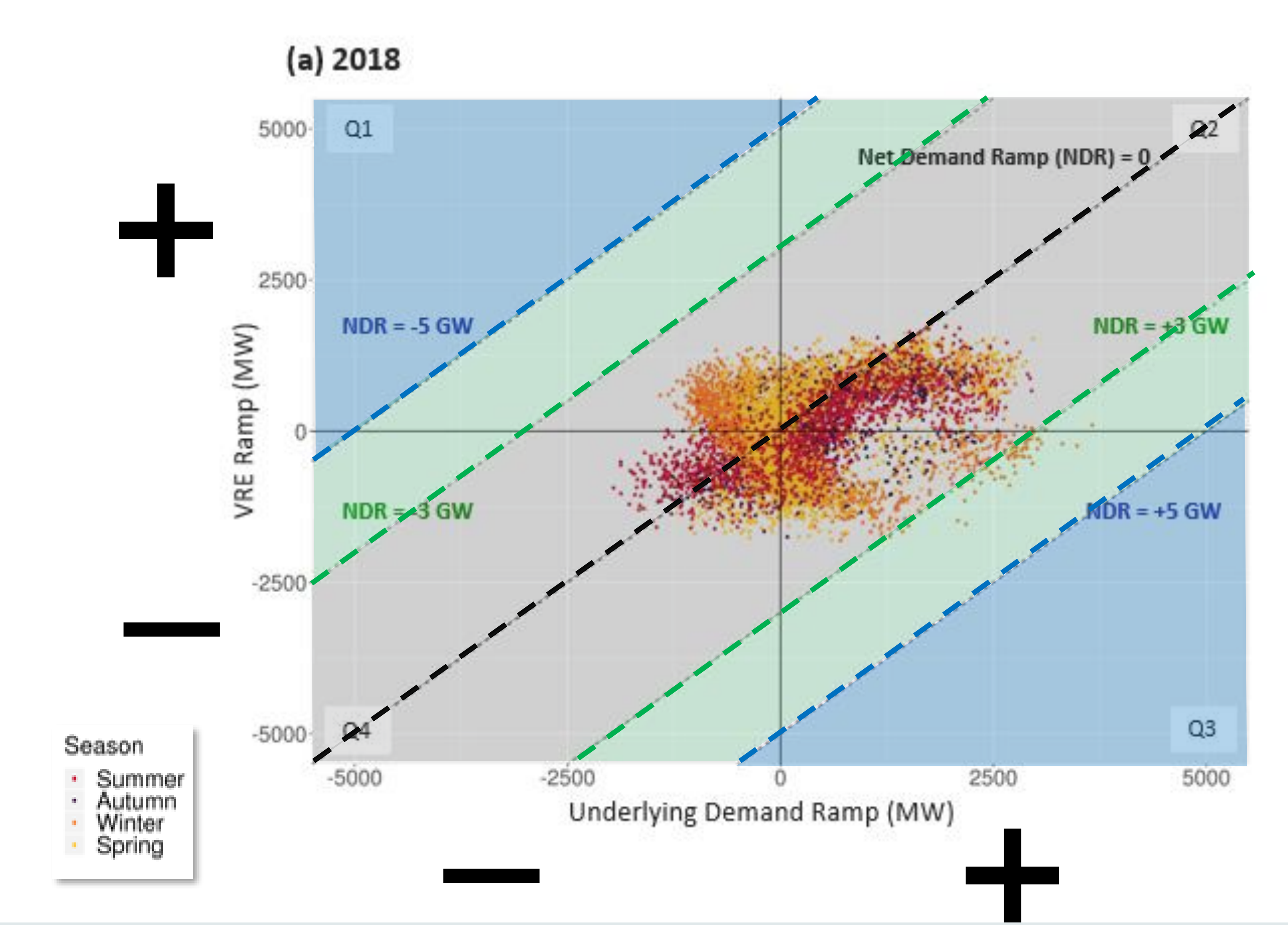


Q2 and Q4 underlying demand and net VRE move in the **same direction**, offsetting one another

Black dotted line is where the offset each other entirely and **net demand ramp is 0**

Q1 and Q3: underlying demand and net VRE move in the **opposite direction,** exacerbating net demand requirements

Interpreting net demand



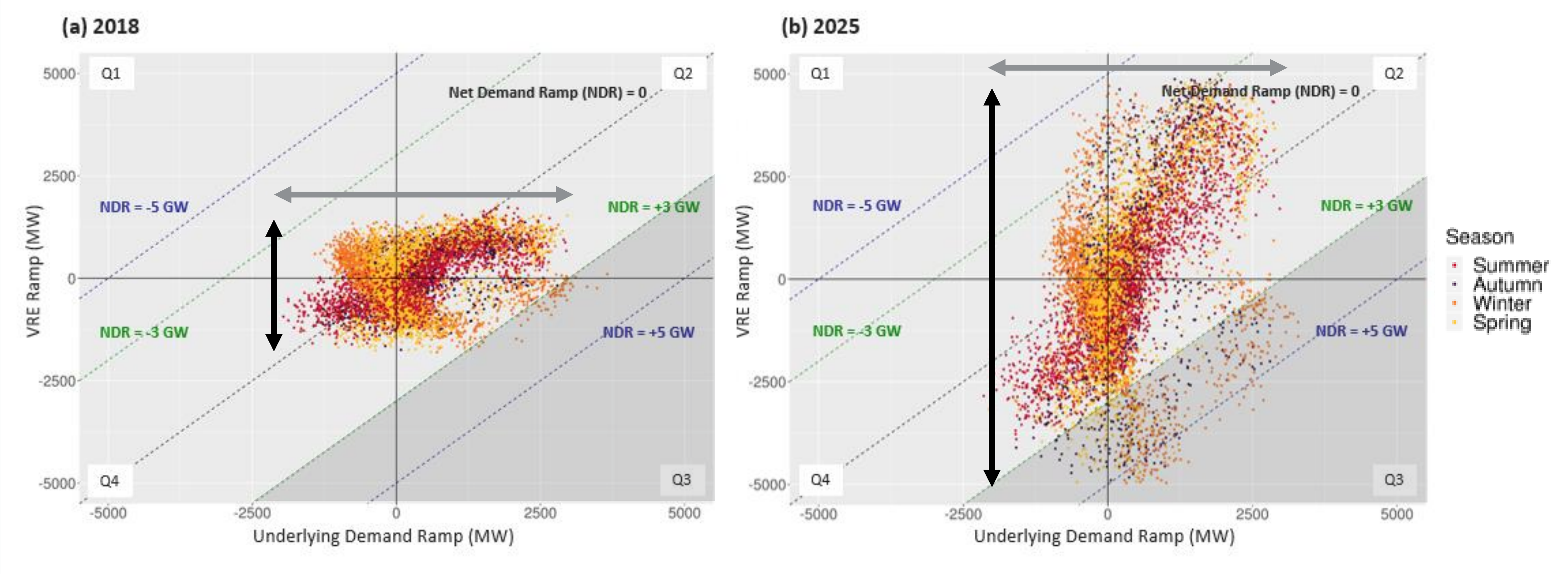
Black dotted line is where the offset each other entirely and **net demand ramp is 0**

Green dotted line shows all **±3 GW net demand** ramp

Blue dotted line shows all **±5 GW net demand** ramp

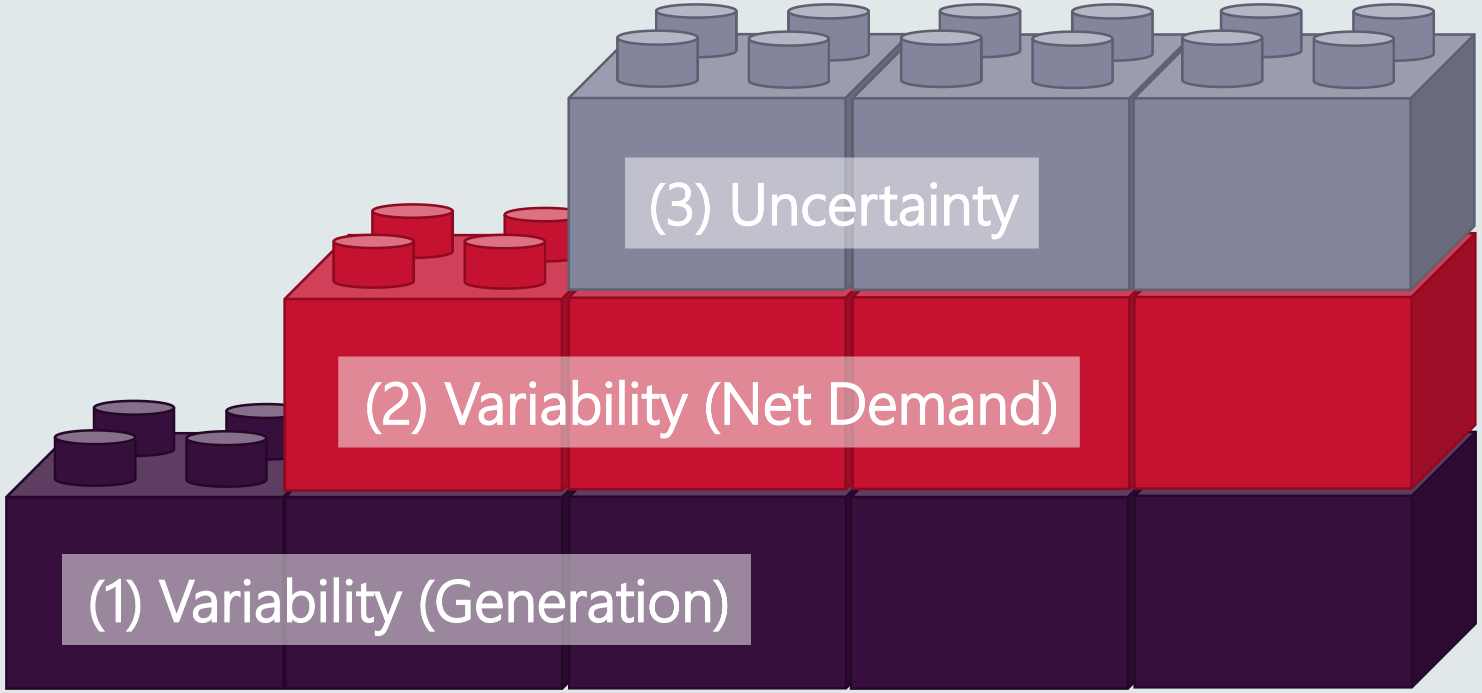
For more information refer to Section C3.4

Increasing net demand



- The magnitude of 1-hour net demand ramps is increasing
- VRE will be a significant driver of ramps in net demand by 2025

Building block #3 – Uncertainty



How well do current forecasting tools predict variability?

Will they be fit for purpose in a more variable system?

- AEMO wind and solar forecasting system data
- 2018 year only
- Utility wind and solar data only
- Multiple ramp windows, lead times, resolutions

For more information refer to Section C4 & C7.1

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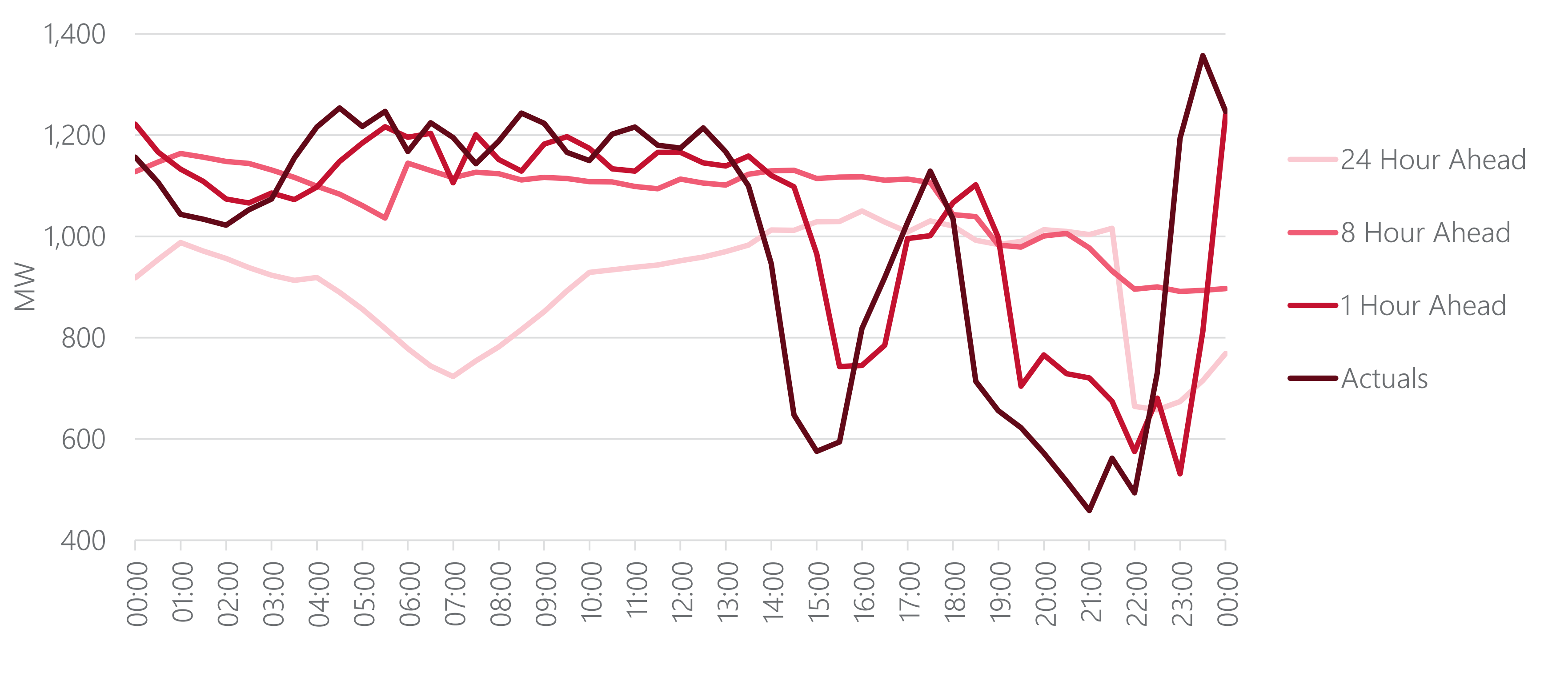
Uncertainty | Case Study | SA 18/12/17



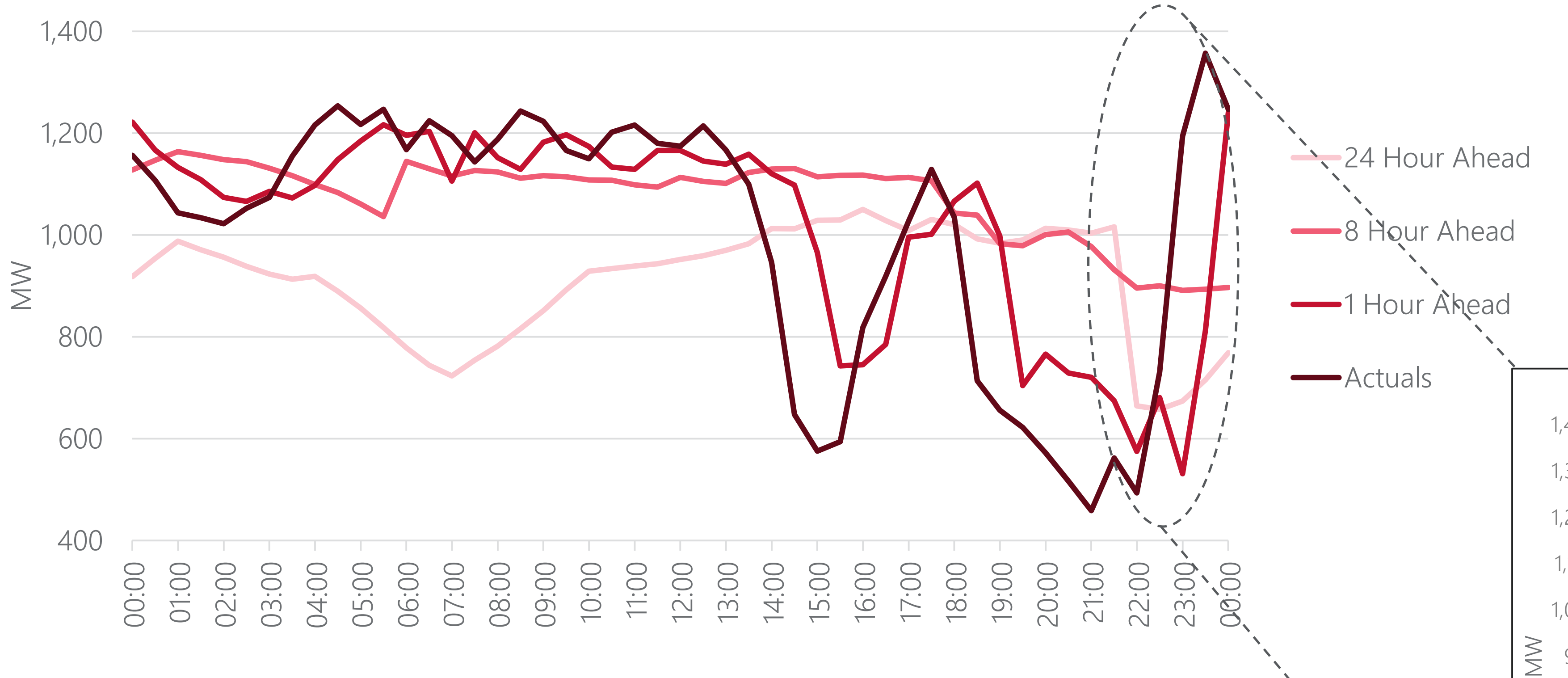
Case study overview

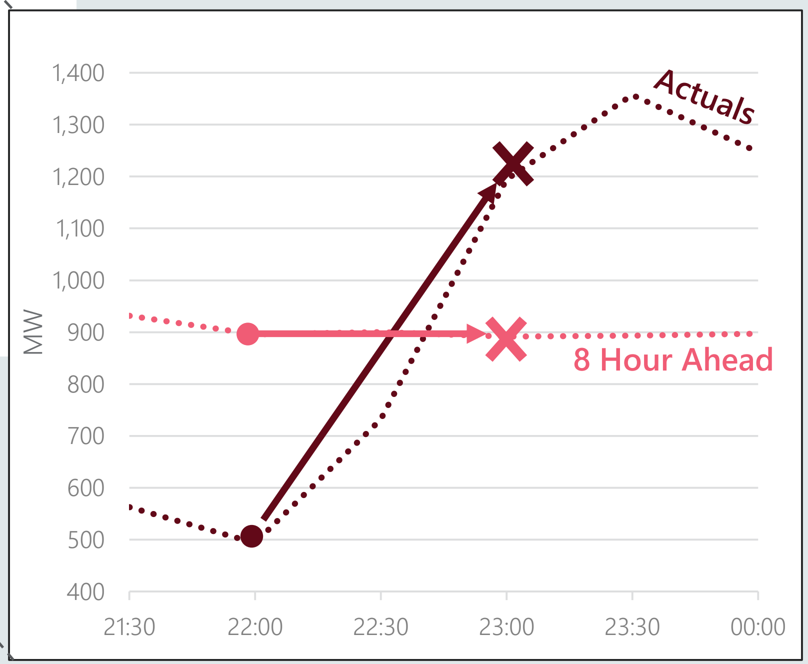
- Wind event in SA
- Low-pressure system and wind shift from NW to SW
- Localised precipitation

Forecast variation in afternoon can be characterised according to model type:

- Models with **longer lead times** (8HA, 24HA) rely on Global Numeric Weather Prediction models
- Models **closer to real time** (1HA) rely on persistence and SCADA from farm

Uncertainty | Case Study | SA 18/12/17

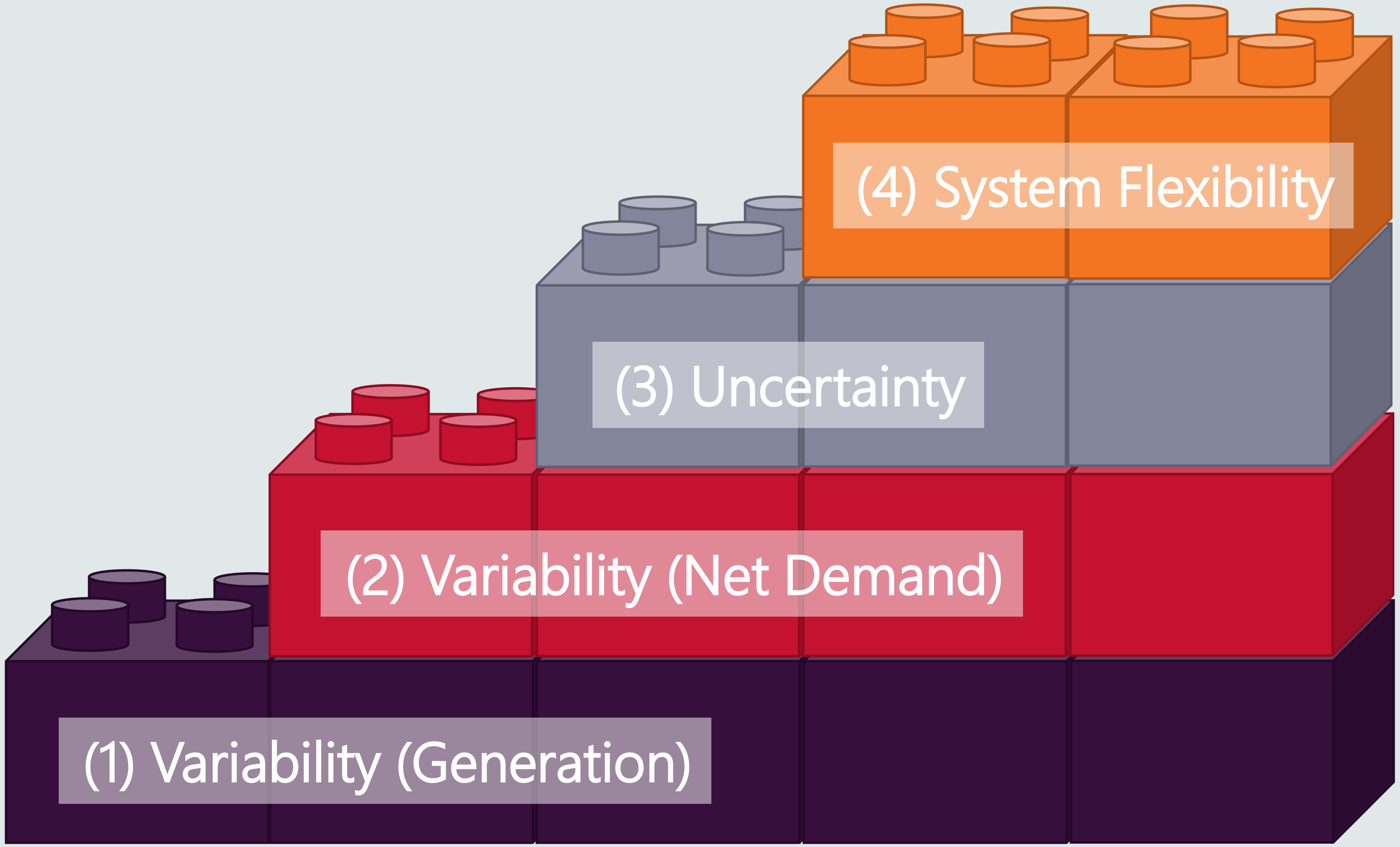




Point forecast error = Forecast MW – Actual MW
= 891 MW – 1,194 MW = **-303 MW**
Output was underforecast by 303 MW

Ramp forecast error = Forecast Ramp MW – Actual Ramp MW
= 2 MW – 701 MW = **-699 MW**
The ramp was underforecast by 699 MW

Building block #4 – System Flexibility

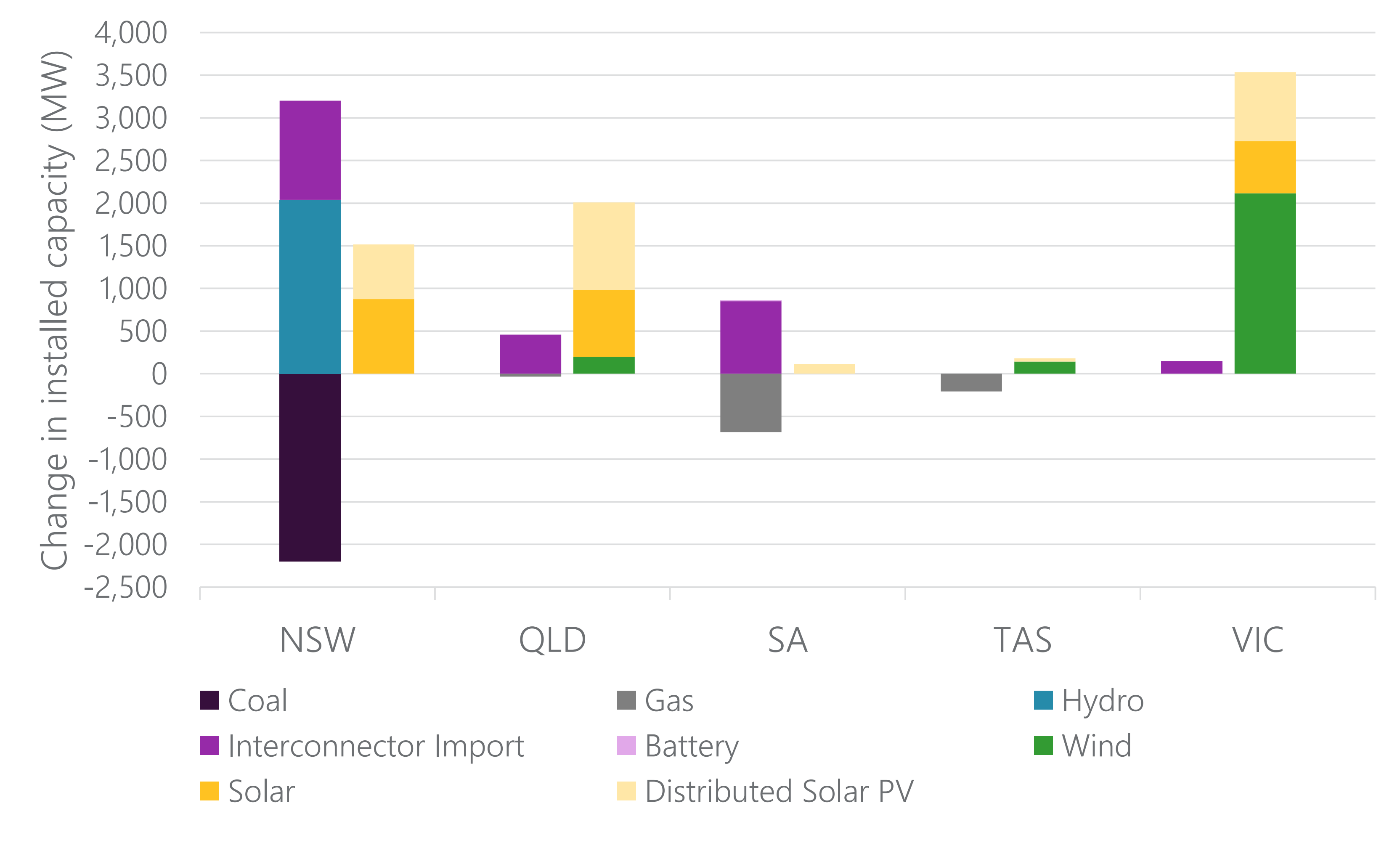


How will the system need to behave to fully utilise wind and solar resources in 2025?

- Outputs from modified Draft 2020 ISP Central Scenario
- Post-processing analysis
- 30-min, 1-hour, 4-hour ramp windows

For more information refer to Section C5 & C7.2

Changing system composition

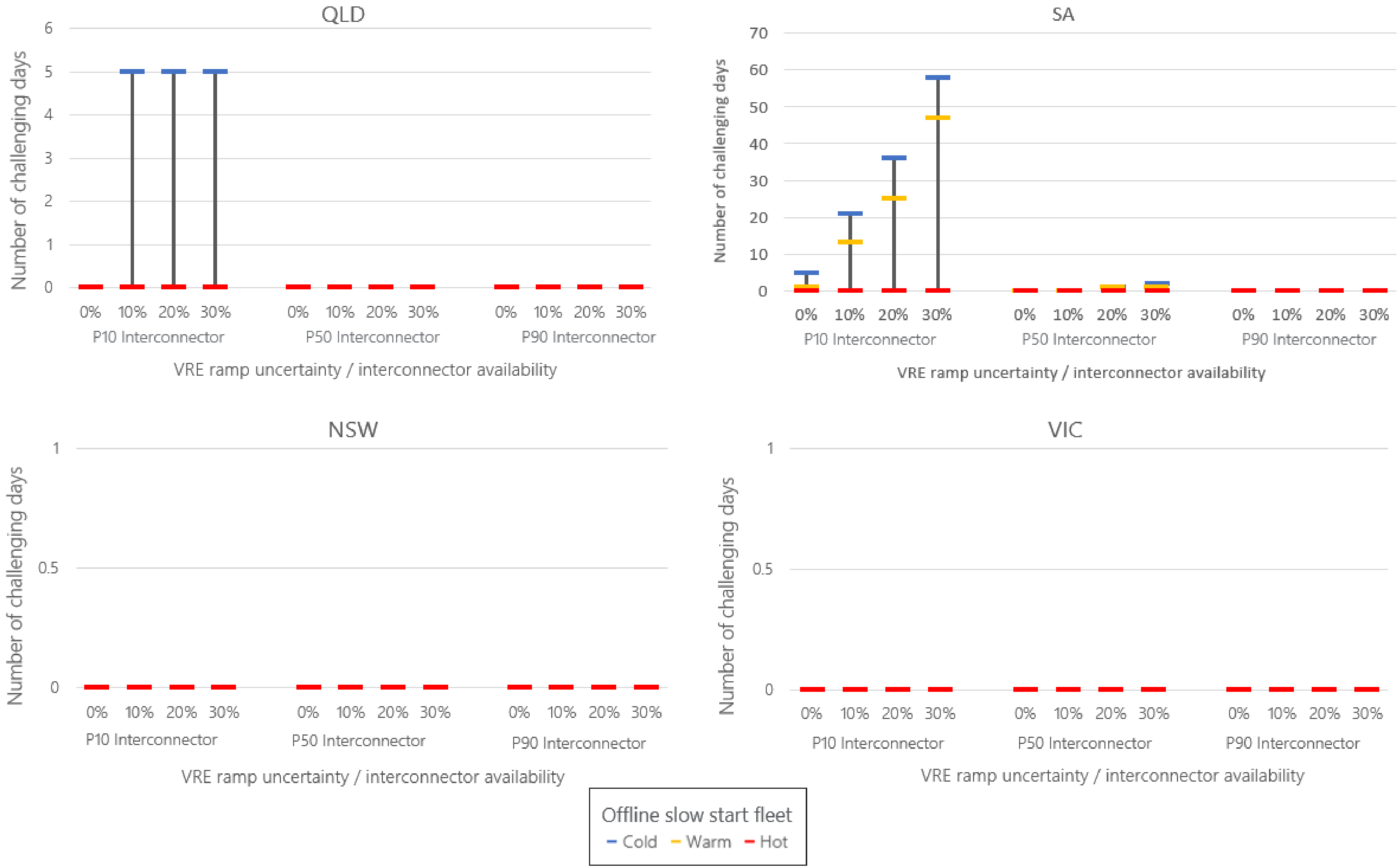


- Range of sources of flexibility in the NEM
- Key changes:
  - Growth in VRE
  - Generation retirements
  - Displacement of online conventional generation
  - Development of other technologies
  - Strengthening interconnection
  - Participant learning

For more information refer to Section C5.1

For more information refer to Section C5.2

Regional flexibility plots | 4-hour ramps



- Number of challenging days in 2025 under interconnector, VRE uncertainty, and offline slow start fleet status sensitivities
- **Challenging days** contain periods where a negative ramping margin was identified when maximising VRE
- **Ramping margin** is the difference between the current ramping capability of the system and ramping requirement

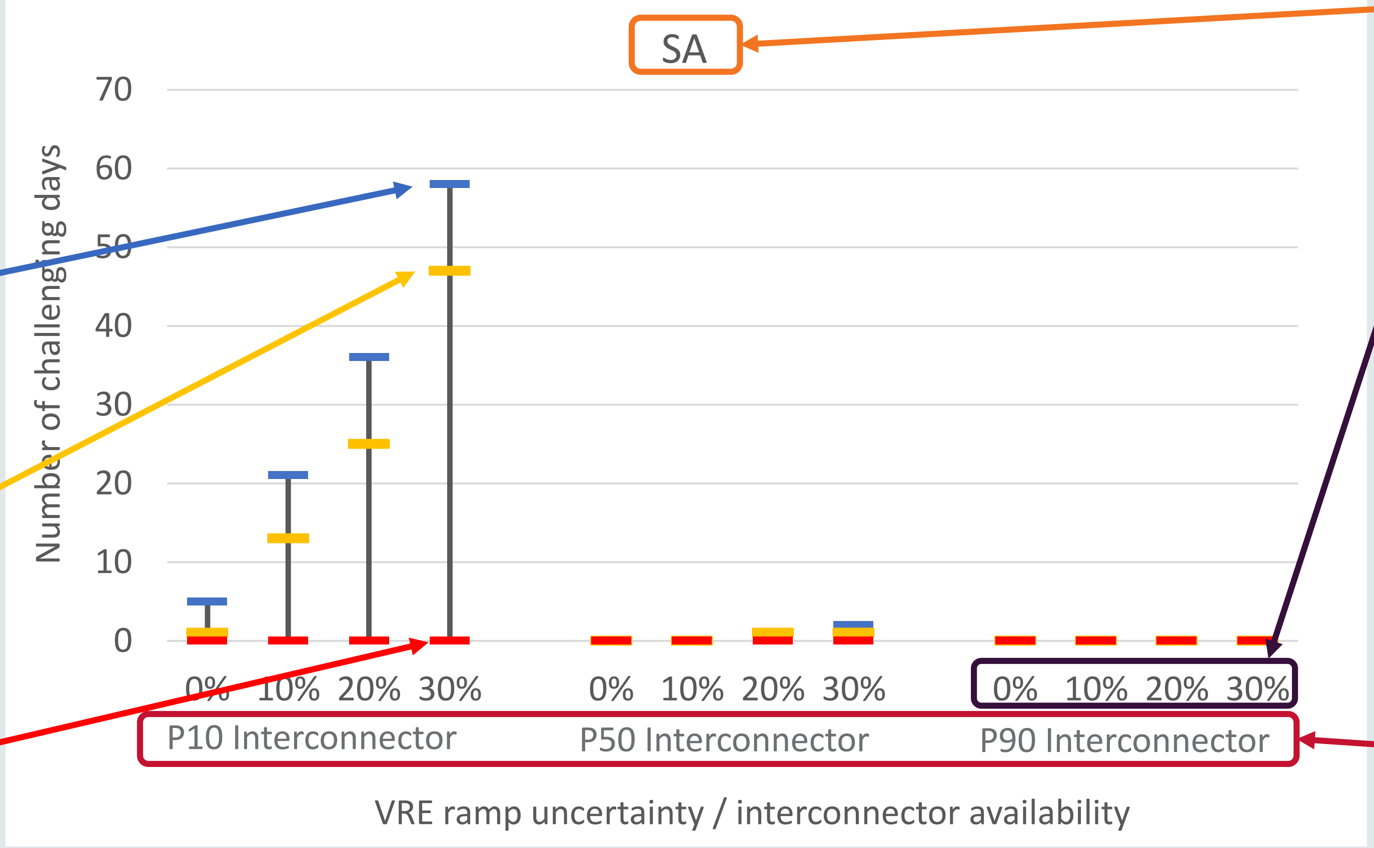
Interpreting flexibility plots

Start up times of offline slow start units:

Cold: Model status retained

Warm: Hot and Warm units retain model status; Cold units brought to warm

Hot: All units hot



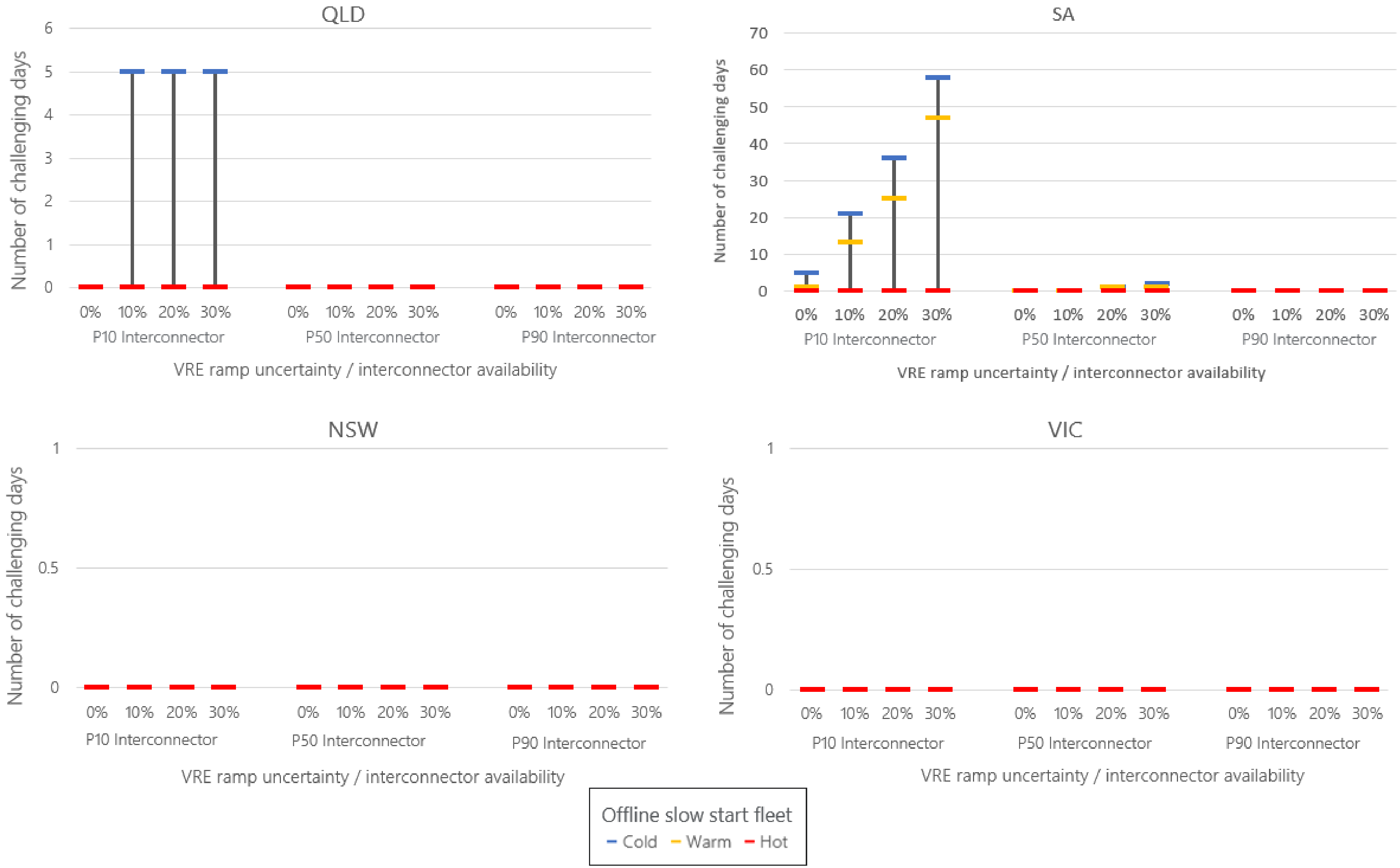
Individual **region** assessment

VRE ramp uncertainty assesses the impact of a downward VRE ramp being 0% to 30% larger than forecast

Interconnector headroom is low (P10), medium (P50) or high (P90)

Percentiles based on PLEXOS model outputs

Challenging days in 2025 | 4-hour ramps

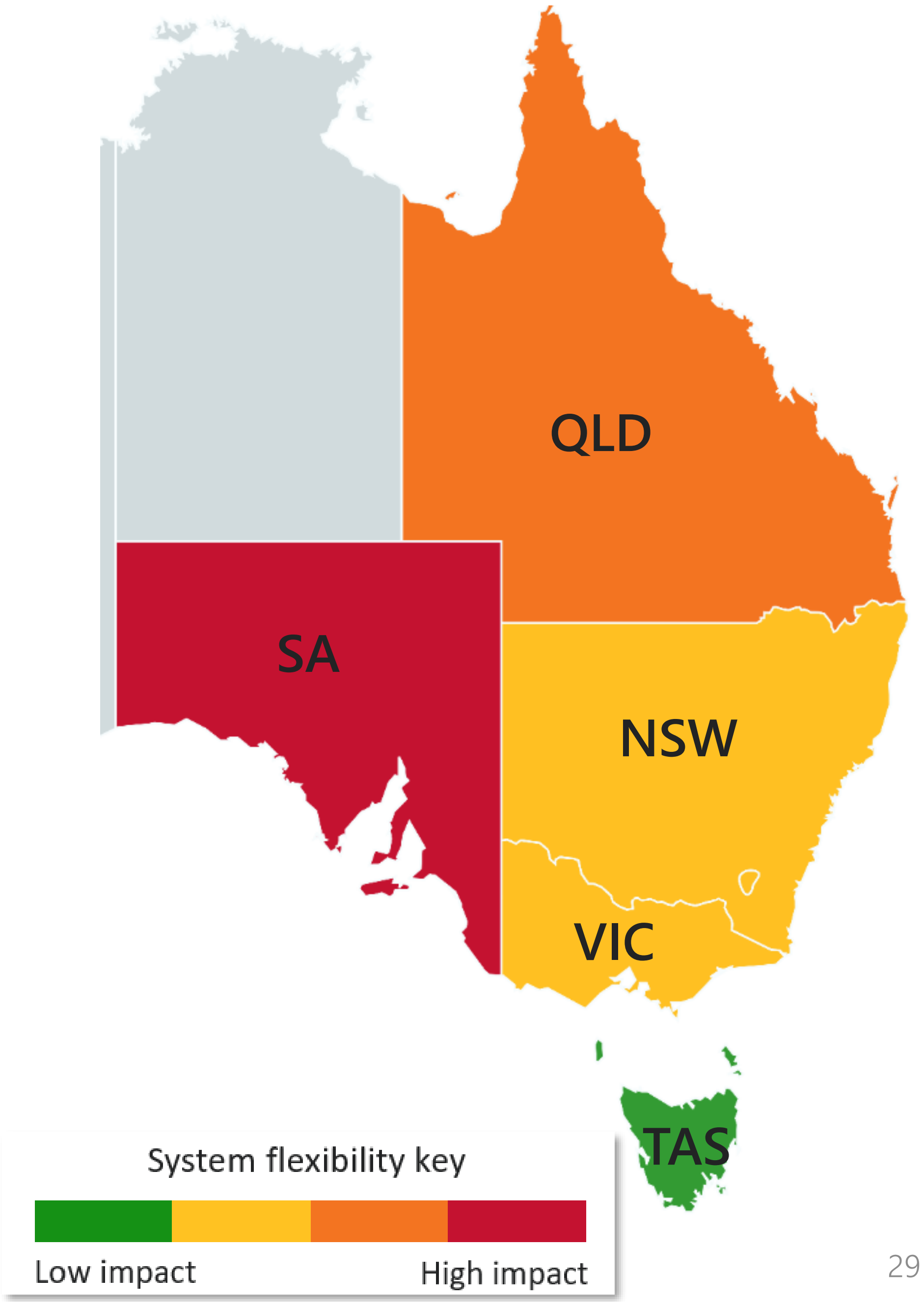


- **South Australia** and **Queensland** are projected to have the most number of challenging days when managing **4-hour ramps** in 2025
- Most challenging days are projected to be when **interconnector availability is low** and units in the offline slow start fleet have been **offline long enough to become cold**

Regional flexibility in 2025

- The drivers behind the supply of flexibility are specific to the **ramping window, region and market behaviour**
- Times of low interconnector headroom or 'cold' offline plant will be more challenging to manage
- The results only give a **relative view** of factors which may have a high impact on flexibility under high penetrations of wind and solar. It shows that:
  - A **range of flexible resources** must be utilised and **planned ahead of time**
  - **Adequate market signals** are needed
  - A **clearer picture** of future system flexibility will emerge as the market's **collective experience grows**
- **South Australia** and **Queensland** are projected to have the most number of **challenging days** when considering all studied ramping timeframes

For more information refer to Section C5.2



Going forward

Summary of findings

The magnitude of peak VRE ramps is forecast to increase by **50%**

Movements in VRE will become the **main driver of net demand ramps** by 2025

Both supply and demand are becoming **harder to predict**

Flexible resources must be utilised and **planned ahead of time**

Flexibility needs to be **harnessed in all parts of the power system**

Demand for **system flexibility** is increasing

Decrease Uncertainty
Increase Flexibility

Operational tools and processes

Regulatory frameworks

Actions going forward

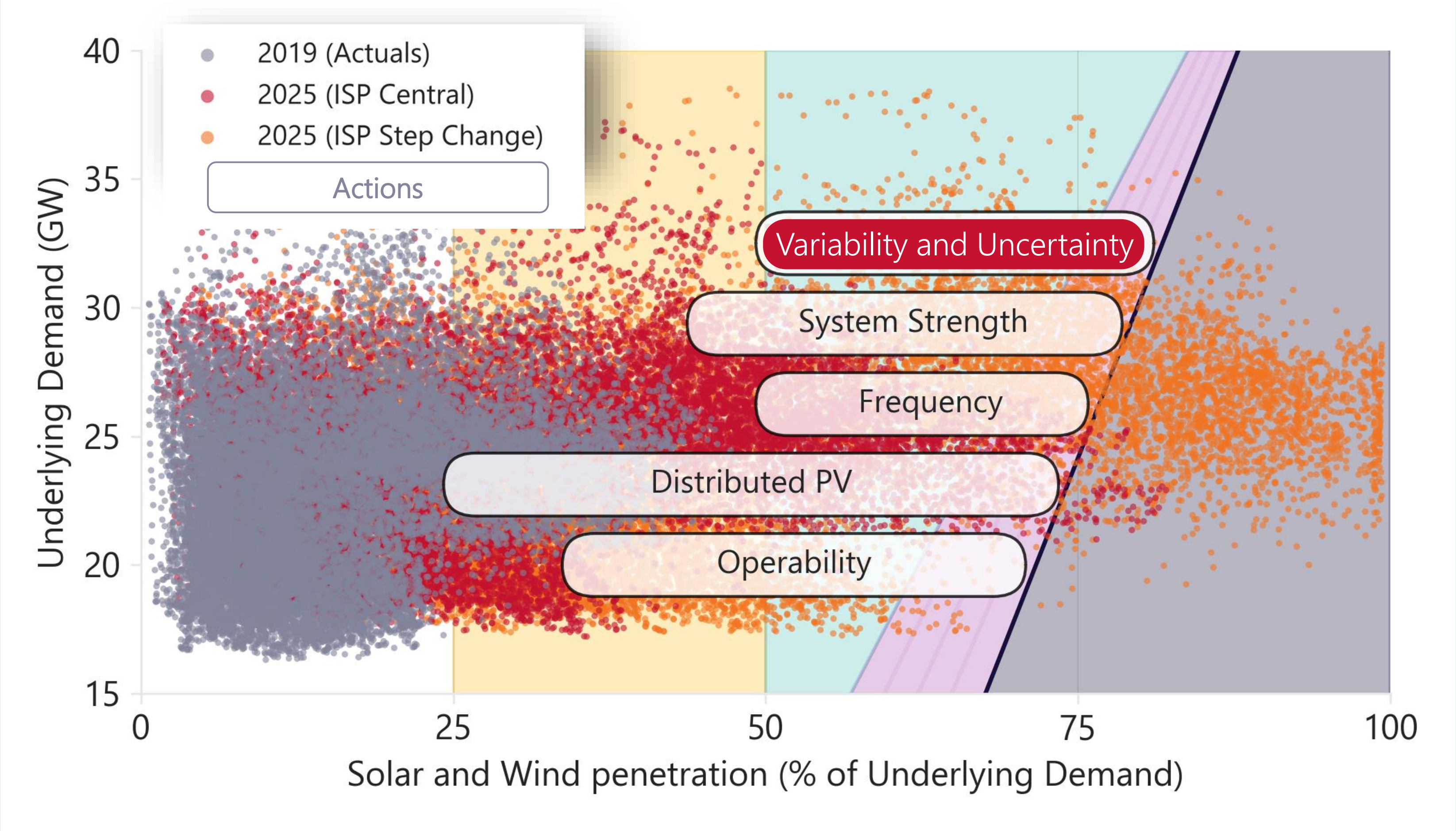
6.1 Adapt **forecasting systems** including improvements to weather infrastructure, ramp forecast and classification prototype

(2.2) AEMO to **redevelop existing scheduling systems** to better account for system needs

6.2 Improve information provided by the VRE fleet to support security constrained dispatch

(2.3) ESB is **assessing market mechanisms** that increase certainty around system dispatch of energy and **essential system services** as real time approaches

Actions to support changing power system



- By 2025 the instantaneous penetration of wind and solar will **exceed 50%**
- The RIS provides an **action plan to securely meet penetrations up to and beyond 75%**
- If **action is not taken, wind and solar may be limited to 50-60%** of total generation
- No insurmountable reasons why the NEM cannot operate securely at even higher levels of instantaneous wind and solar penetration in future

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