Distributed PV

An overview of the RIS Technical Appendix A

Watch the whole series

- Renewable Integration Study 101
- Renewable Integration Study Technical Overview
- Distributed PV
- Managing Frequency
- Variability and Uncertainty

RIS series available at: https://www.aemo.com.au/energy-systems/Major-publications/Renewable-Integration-Study-RIS

Presenters

Rama Ganguli

RIS stream lead
Future Energy Systems
AEMO

Taru Veijalainen

RIS Senior Analyst
Future Energy Systems
AEMO

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Today's Webinar

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

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Key Concepts

Distributed PV

What is it?

Distributed Photovoltaics (DPV) convert the sun's rays to electricity, and includes all grid-connected solar that is not centrally controlled.

DPV is a type of **Distributed Energy Resource (DER)** – includes batteries and electric vehicles.

Residential
< 10kW

Commercial
10 kW to 100 kW

Industrial
100kW to 30 MW

2009

Only **~10,000 systems** installed across the NEM

Total installed capacity of DPV was **35MW**

Today

Over **2.2 million** DPV systems installed across the NEM

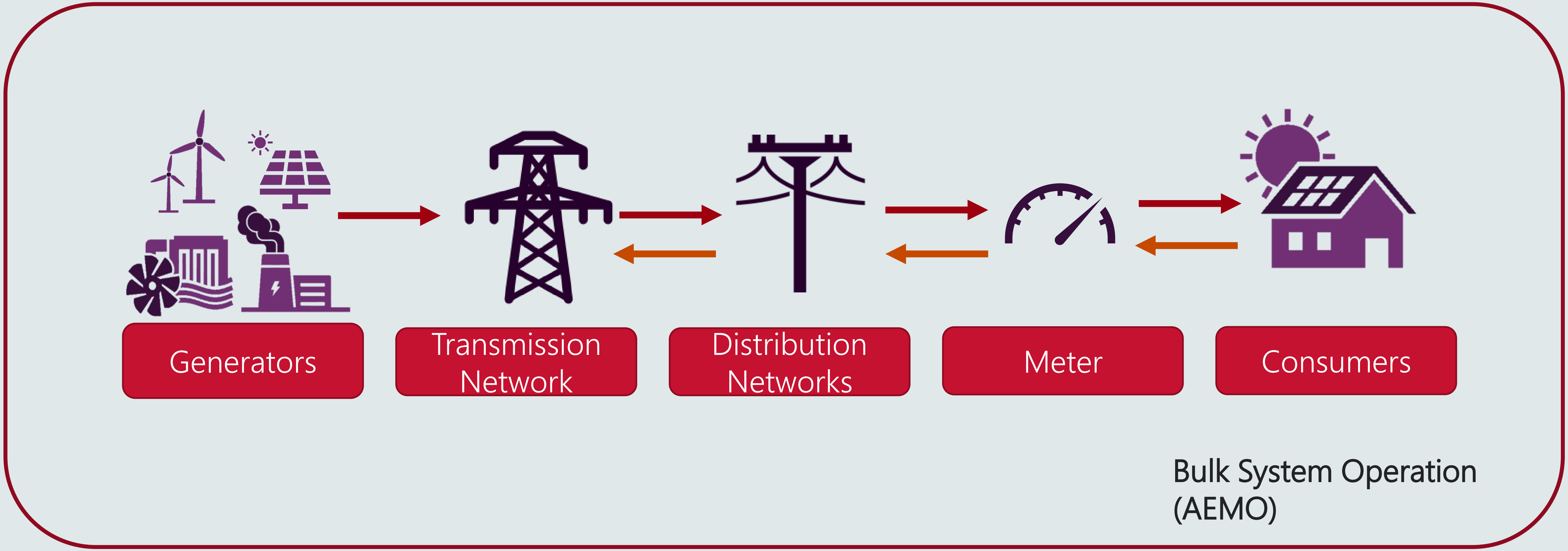
Collectively DPV is now the **largest generator**

2025

Installed DPV could be **>25x the largest coal generator** in the NEM

DPV to reach **37 – 50%** instantaneous NEM demand

Electricity supply chain



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DPV from a system operator's perspective

- **Asynchronous** (see Appendix B)
- **Variable** (see Appendix C)
- **Decentralised**

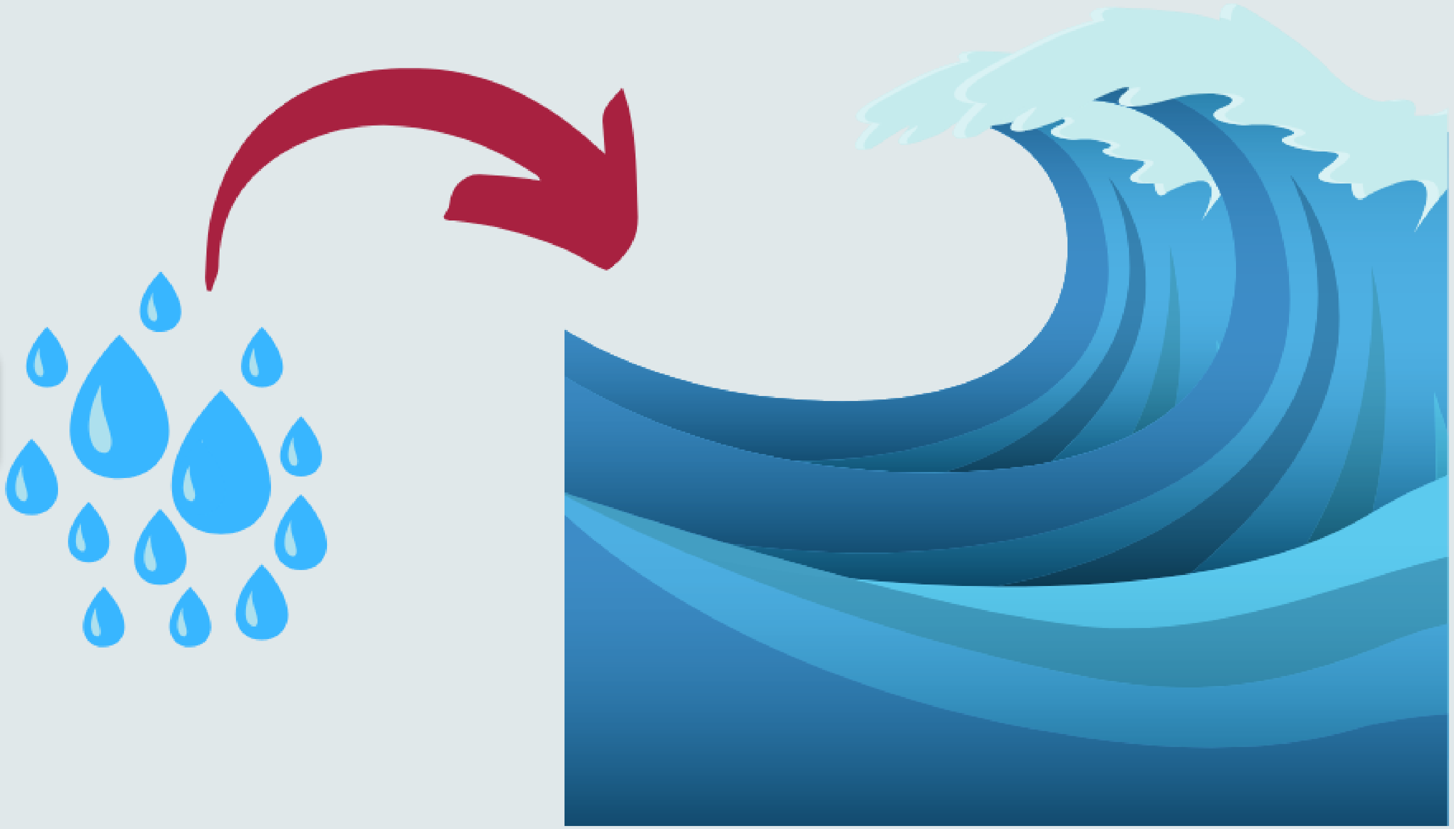
	Large-scale Generation	DPV
Visible	✓	✗
Performance aligned to power system needs	✓	✗
Controllable	✓	✗

DPV is connected via **power electronic equipment** called **inverters**

From the system operator's view this is a **passive** generator

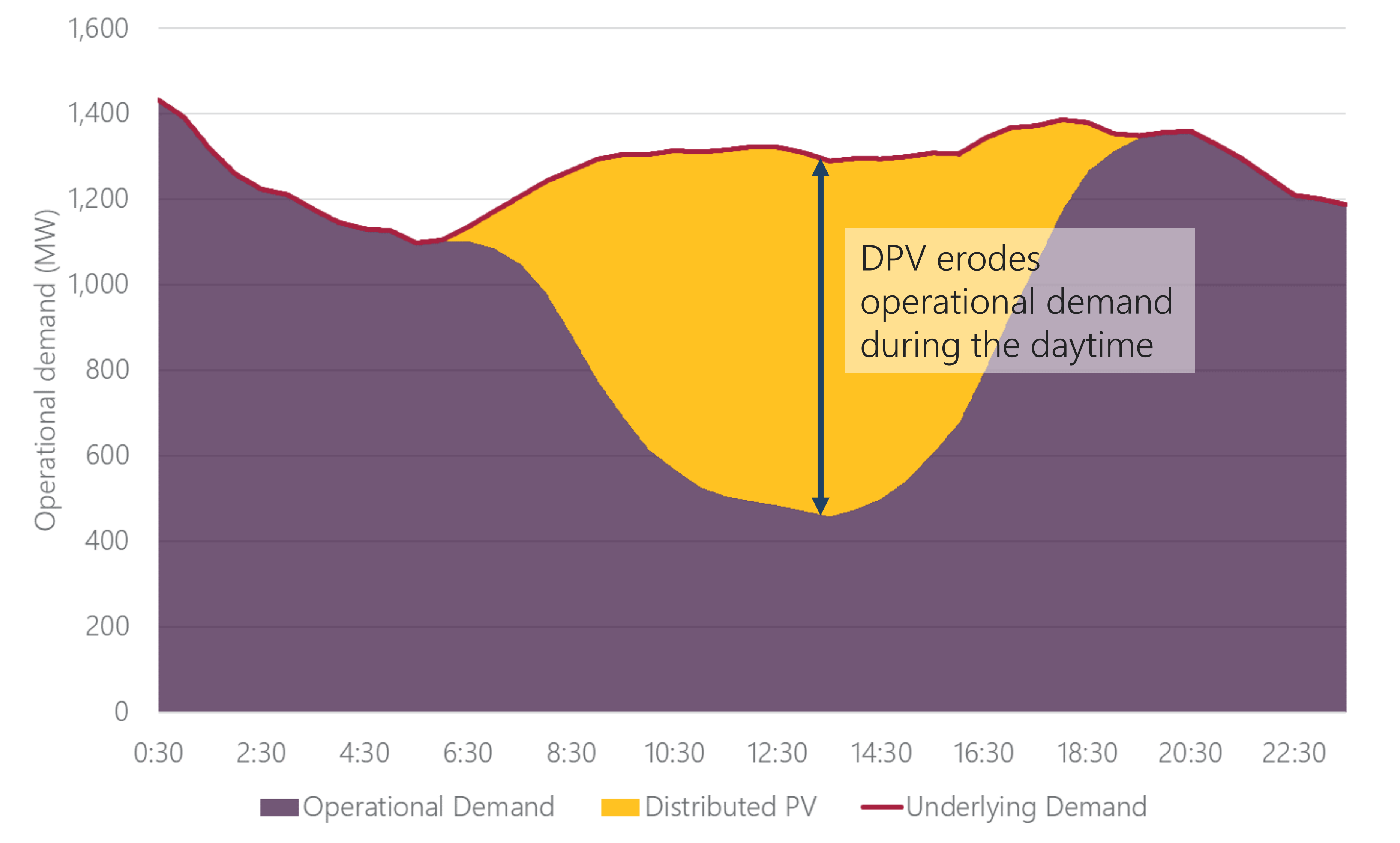
Why is it of interest?

Individually small, passive devices



Large and growing aggregate impact

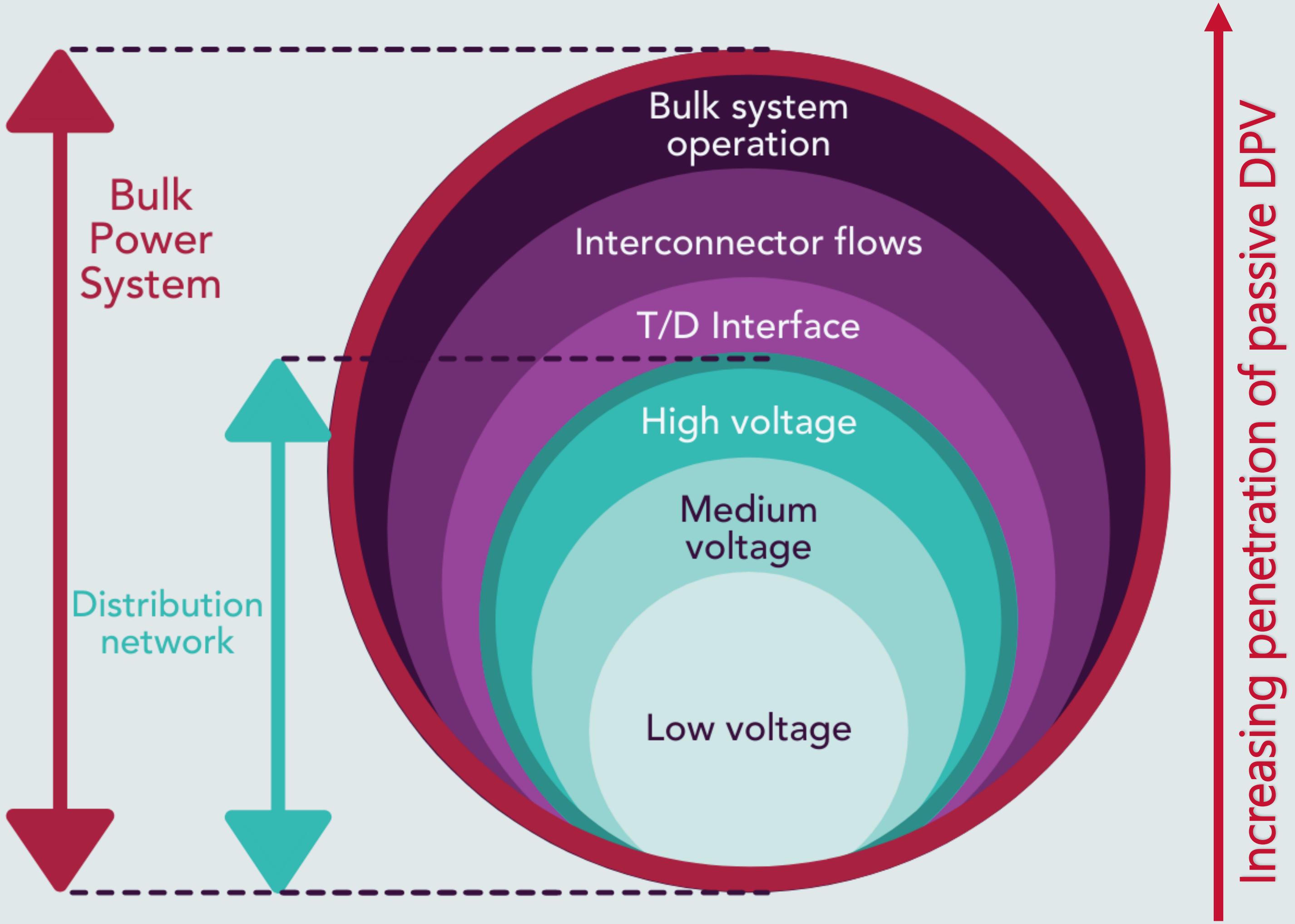
Operational Demand



Approach

What did we investigate?

1. What are the technical limits to increasing passive DPV generation?
2. How might challenges be experienced out to 2025?
3. How could these limits be addressed?



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For more information refer to Section A2

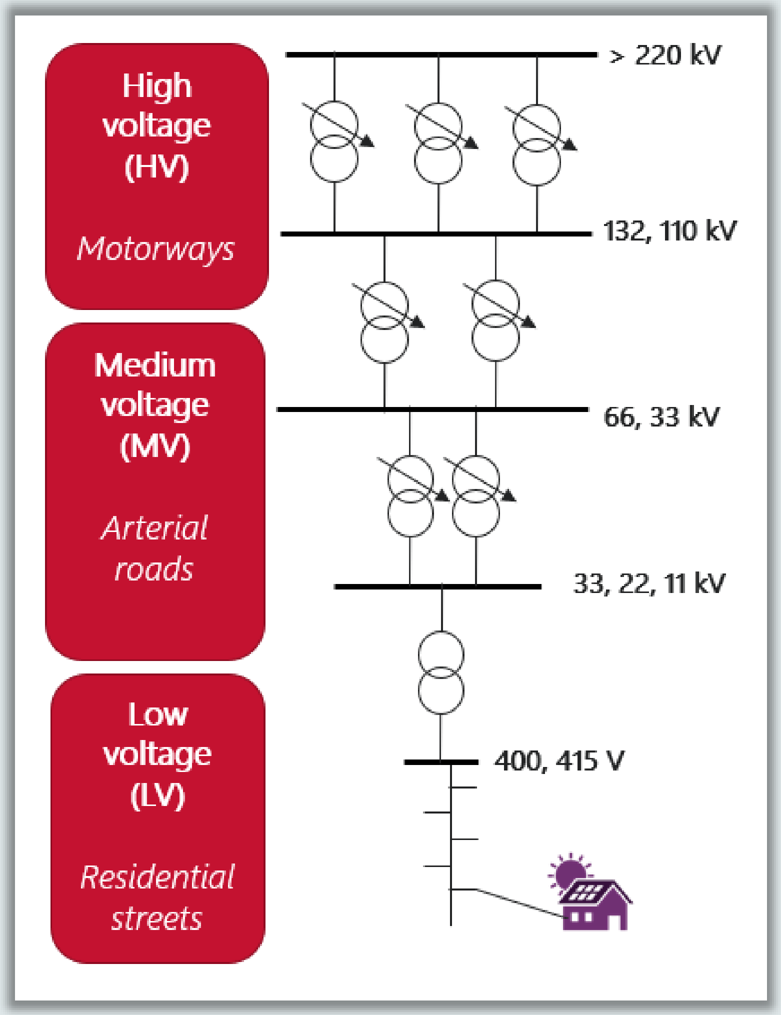
Core areas of analysis

Distribution network challenges

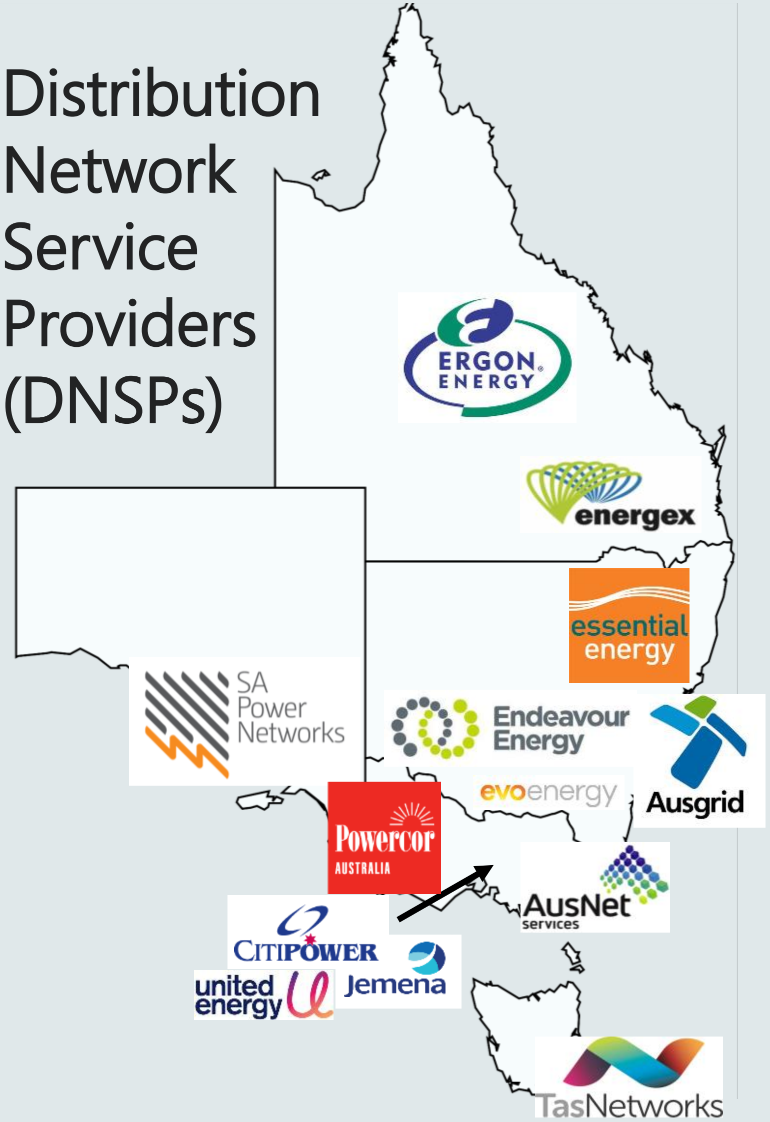
Distribution networks

For more information refer to Section A3

- Transport electricity generated in the bulk power system to end users
- **Feeders:** overhead lines and underground cables for transport
- **Substations:** house transformers stepping down power to lower voltages



Distribution Network Service Providers (DNSPs)



Challenges

For more information refer to Section A3.2 and A3.3

Local generation DPV offsets demand to the point where **power flows on the LV feeders are reversed at times.** This can result in several **integration challenges** within the distribution network.

Voltage management

Solar peak voltage rise while still managing evening peak demand voltage drop

Thermal ratings

Reverse flows exceeding the carrying capacity of equipment

Protection co-ordination

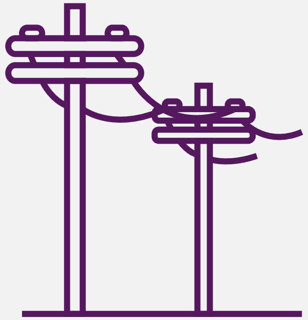
Proper operation of schemes recognising and clearing faults in the network

All DNSPs beginning to experience **LV network management** challenges. Significant **clusters of DPV generation impacting MV and HV network operation** in certain locations.

Challenges **most significant in SA and Qld today** but expected to become **increasingly prevalent across all regions by 2025**

Solutions

For more information refer to Section A3.4 and A3.5



Network strategies

- Remediating and reconfiguring network assets
- Adding network capacity
- Embedding grid-scale storage
- Enhancing operational flexibility

Behind-the-meter strategies

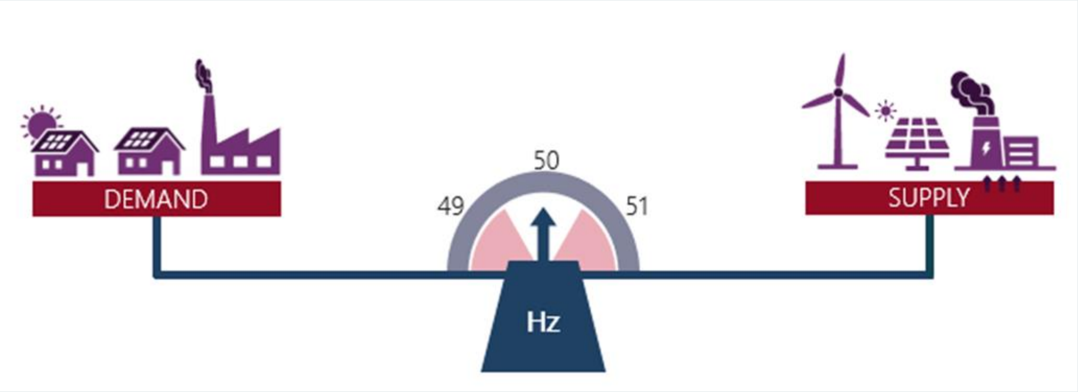
- Reconfiguring settings or limiting export from DPV systems
- Actively managing DPV generation
- Activating load and storage to ‘soak up’ excess DPV generation

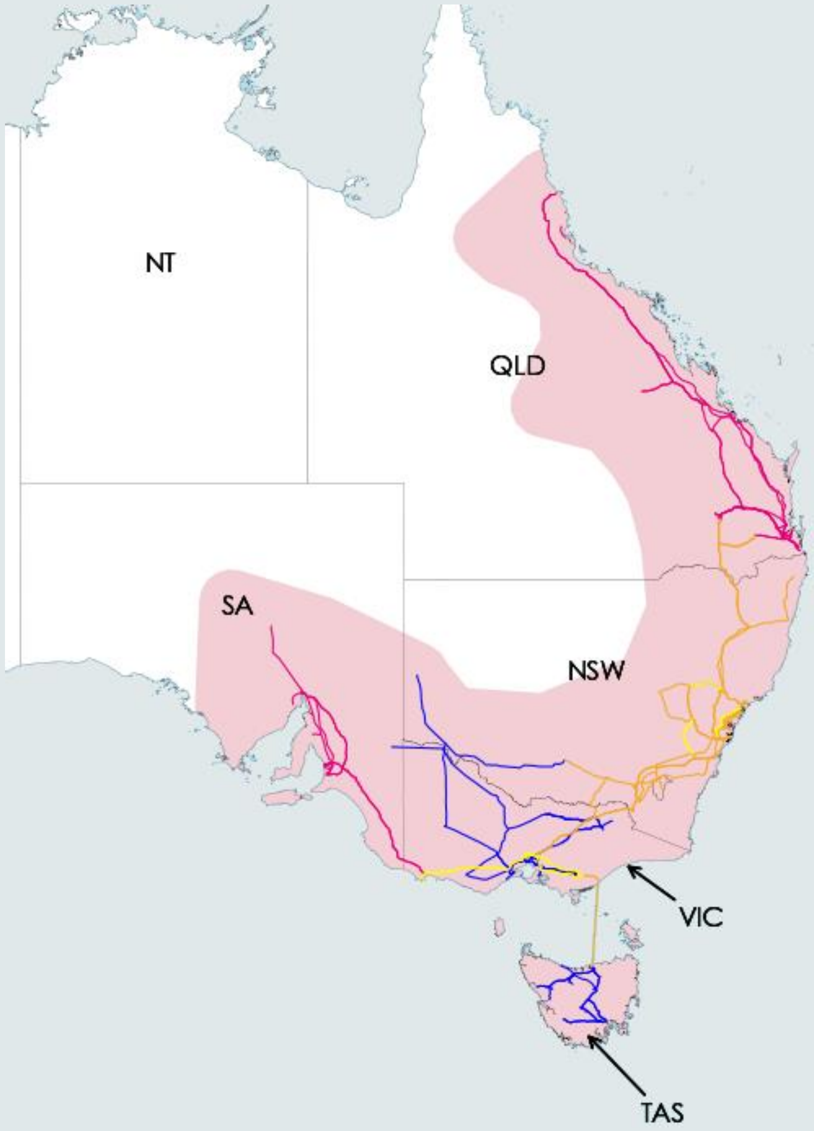
Visibility is a key enabler for optimised, efficient DPV integration

Bulk power system challenges

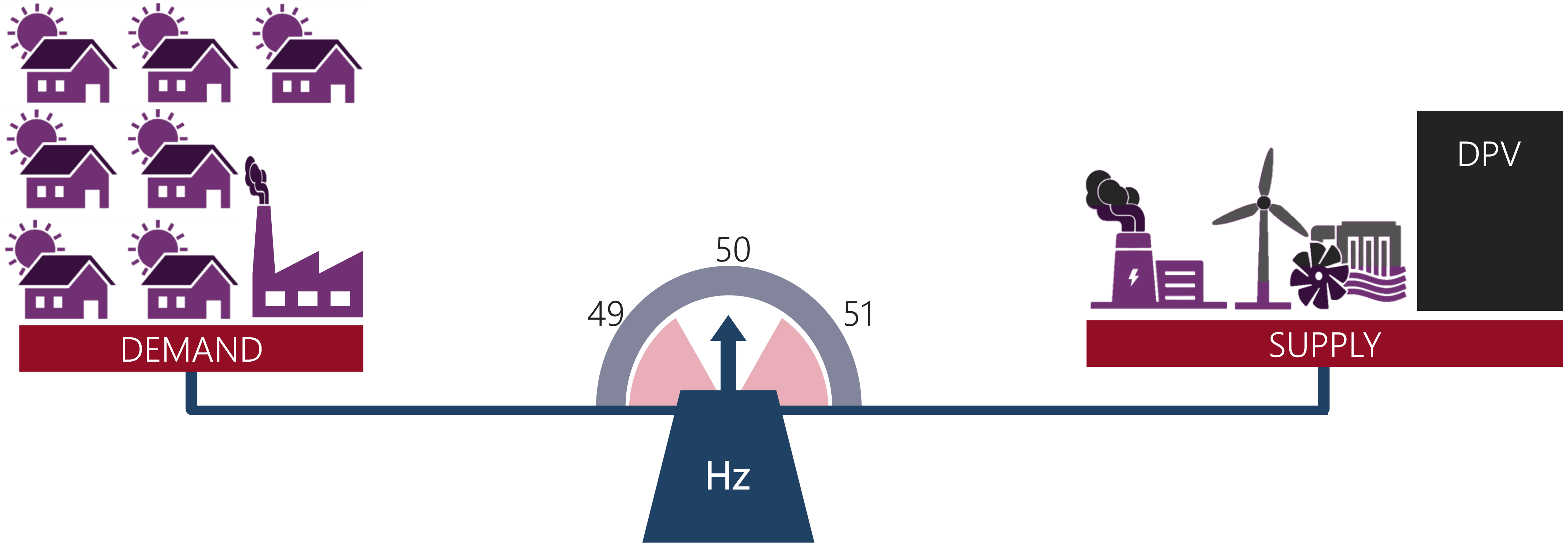
Bulk power system

- Supply and demand are **balanced continuously and instantaneously**
- The NEM operates at **50 Hz**
- Deviating too far can cause **damage to equipment**, or disconnection.
- Historically, we have done this by dispatching **large scale generators**





What is the impact of DPV generation on system balancing?

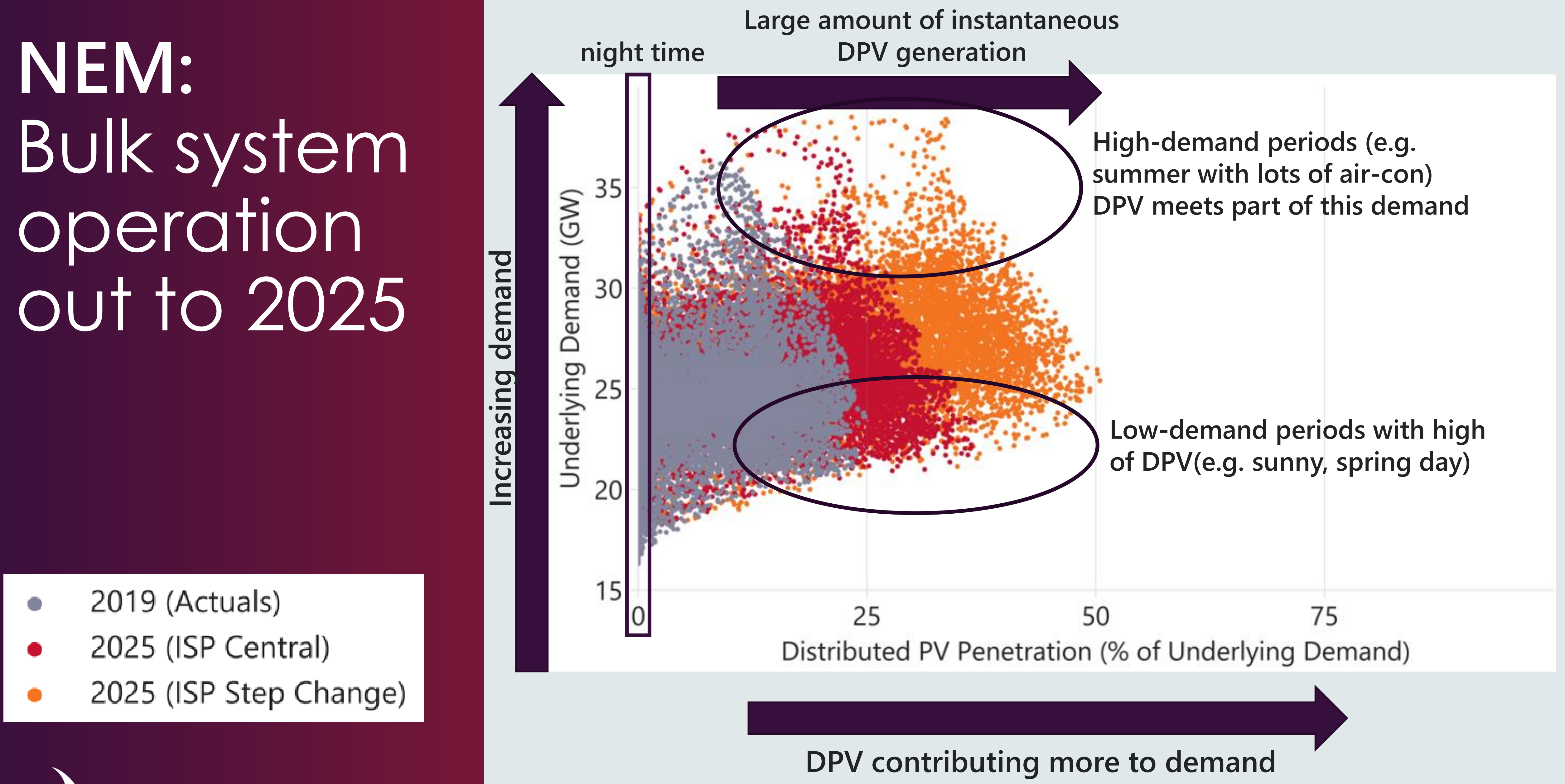


What are the operational challenges?

Performance during power system disturbances	Contingency risks associated with mass DPV disconnection		
Ongoing reduction in operational demand	Minimum synchronous generation requirements	Stable load for emergency mechanisms	Transmission network voltage control
Increasingly large source of variable generation	Daily ramps associated with DPV generation	Sub-regional ramps due to cloud movements	
Increasing source of generation that cannot be curtailed	Power system dispatchability	Operational levers during extreme abnormal conditions	

For more information refer to Section A4

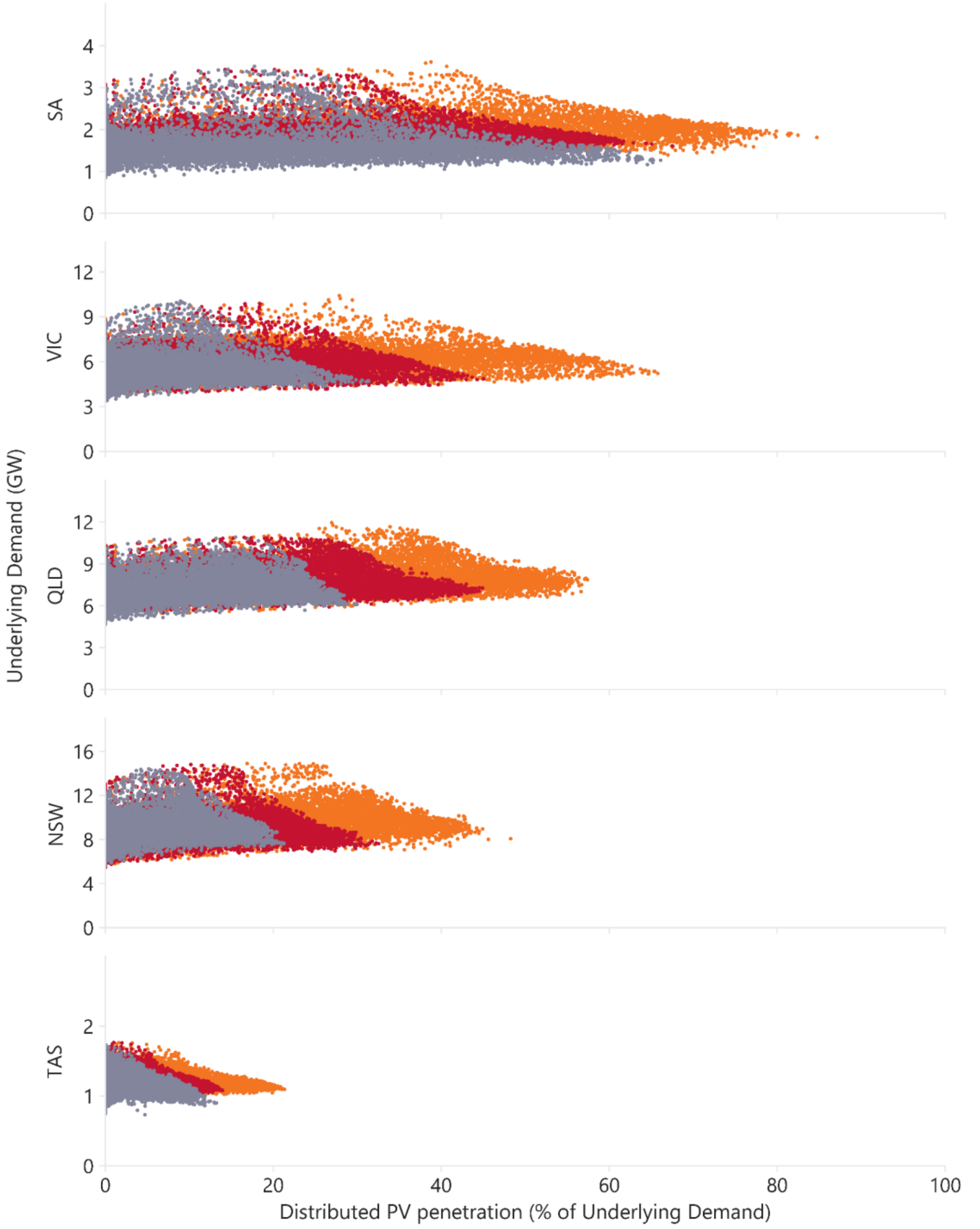
NEM:
Bulk system operation out to 2025



For more information refer to Section A2.3

Regions: Bulk system operation out to 2025

- 2019 (Actuals)
- 2025 (ISP Central)
- 2025 (ISP Step Change)



For more information refer to Section A4.4

Zone A:

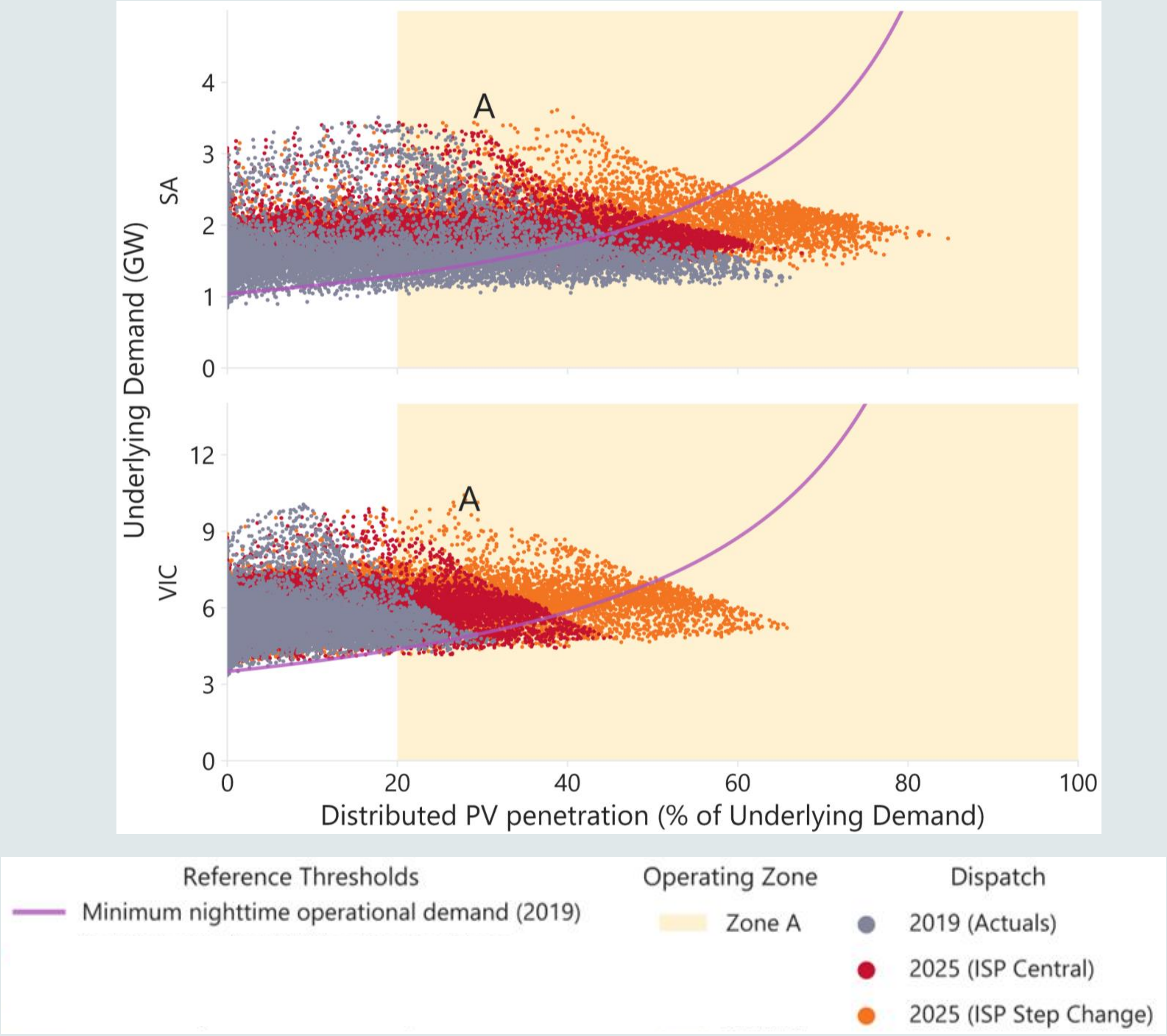
Noticeable impact on the system load profile

Stable load for emergency mechanisms

Transmission network voltage control

Daily ramps associated with DPV generation

Sub-regional ramps due to cloud movements



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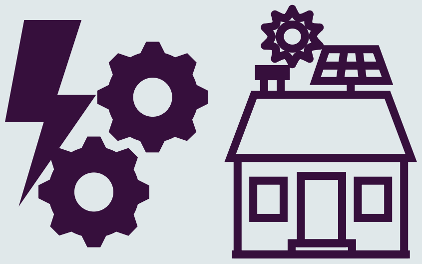
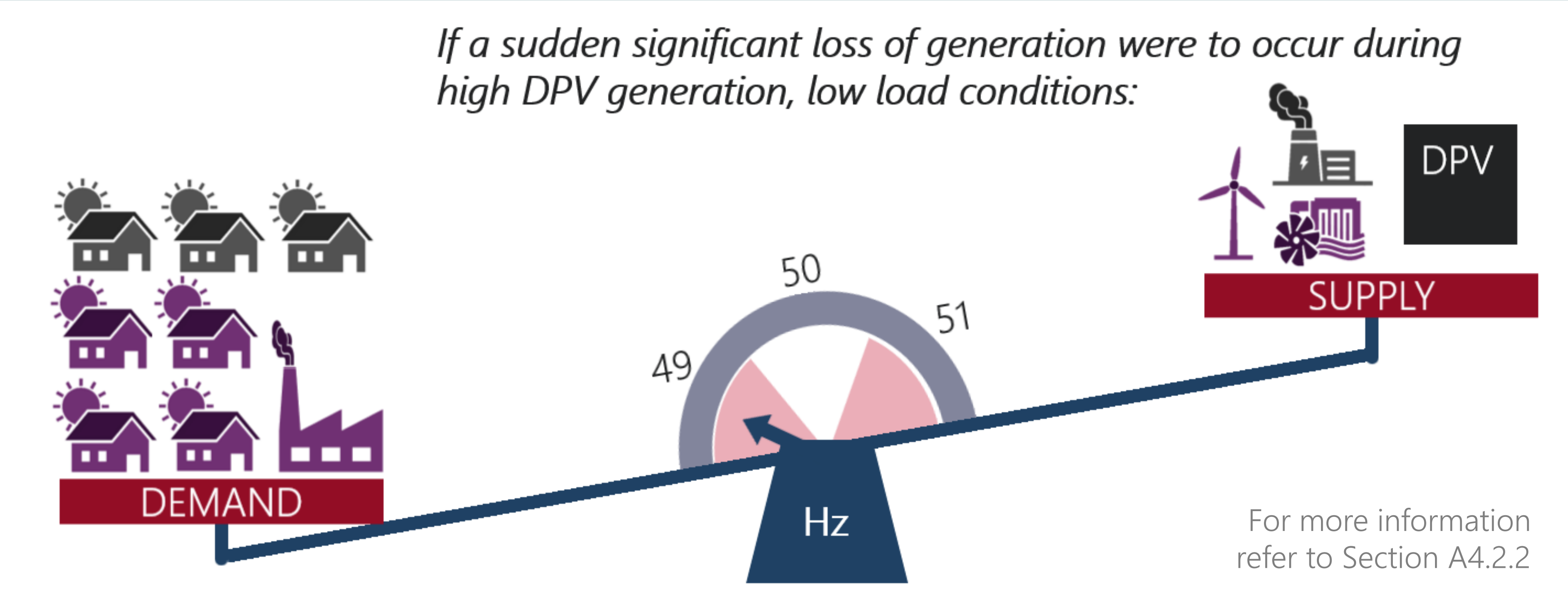
Case study: Effectiveness of under-frequency load shedding (UFLS) schemes



DPV generation is reducing the amount of **stable load for emergency mechanisms**

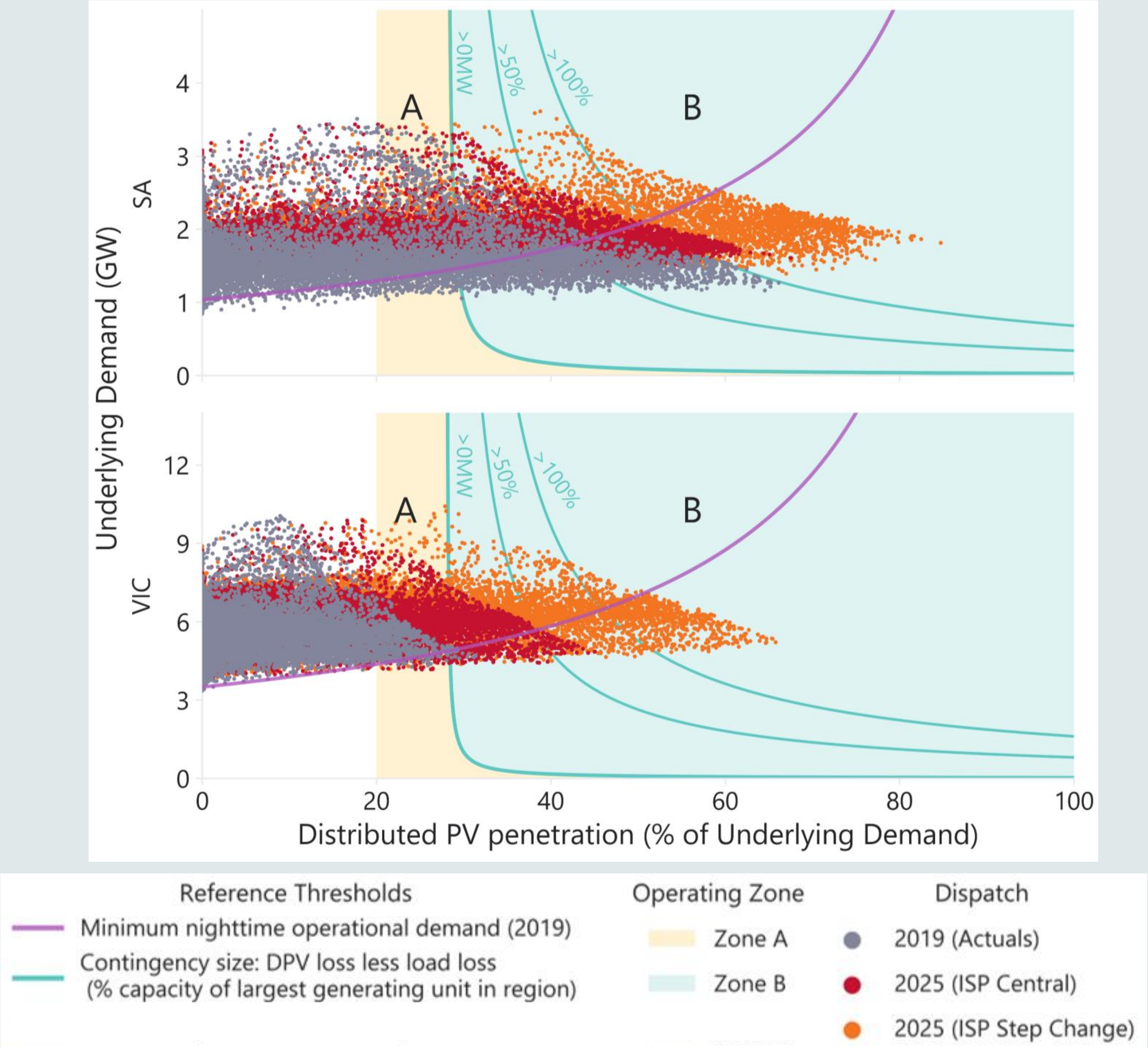


- **Today** there may already be **insufficient load available** for shedding
- **By 2021** in SA **85%** of UFLS schemes could be in **reverse flow, exacerbating disturbances**
- **By 2025 all regions** will have **significant reductions** in load available for UFLS

Zone B:

Material risk of mass DPV disconnection

Contingency risks associated with mass DPV disconnection



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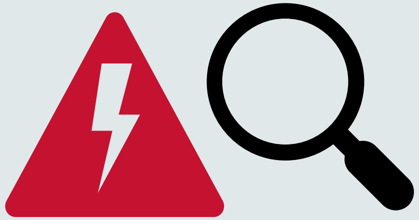
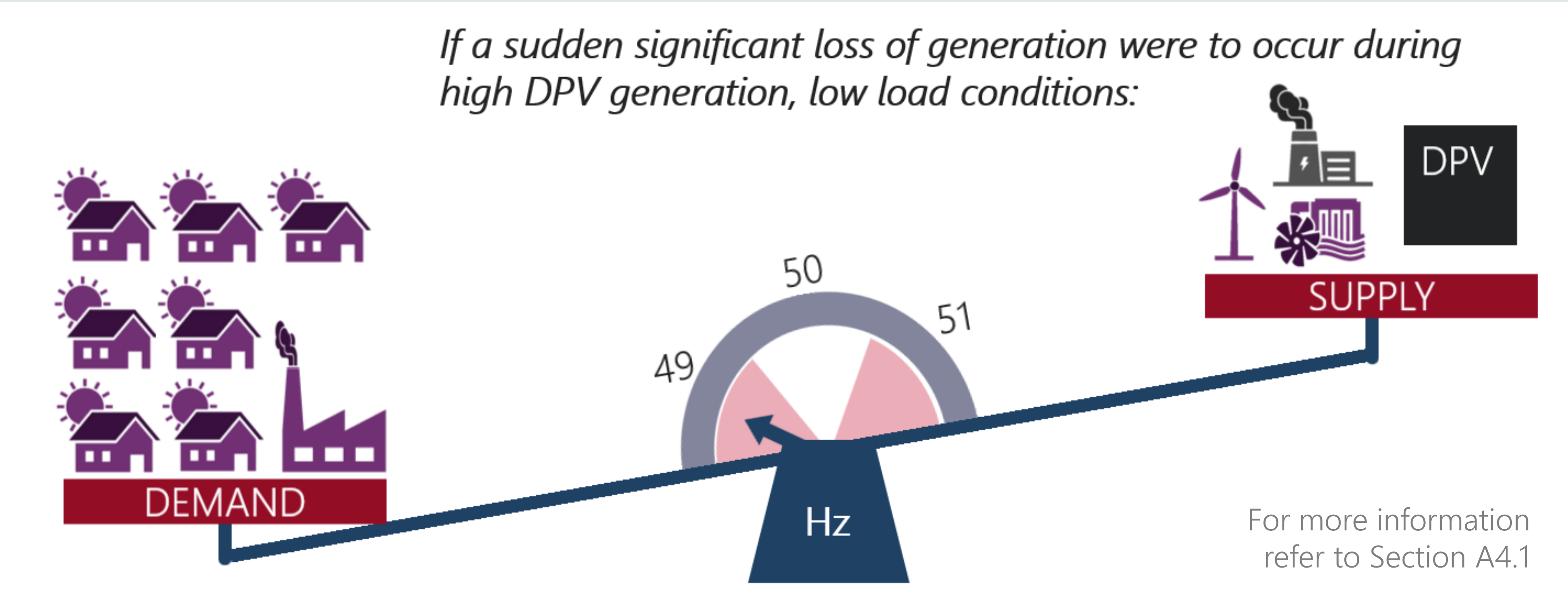
Case study: mass DPV disconnection risk in the Adelaide metro area



There is now a considerable evidence of **mass DPV disconnection** following disturbances



- AEMO has **limited effective tools** available to manage this additional impact on contingency sizes
- **Today** in SA may have already exceeded contingency sizes where **UFLS is inevitable**
- **By late 2020** in SA the net loss of DPV and load is sufficiently large that **cascaded tripping** and **major supply disruption** might be **inevitable** under these circumstances

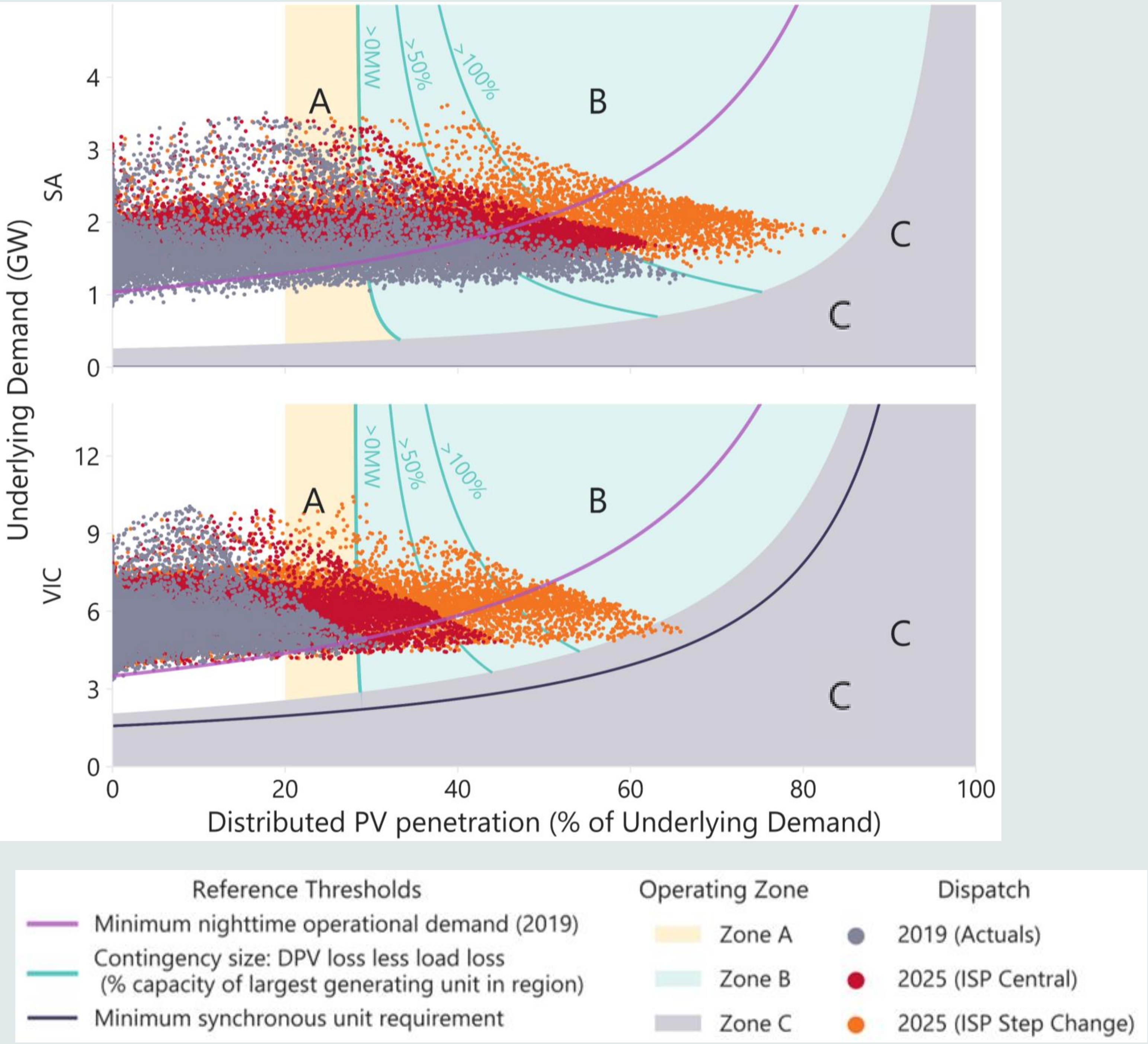
Zone C:

Insufficient load for system security

Minimum synchronous generation requirements

Power system dispatchability

Operational levers during extreme abnormal conditions



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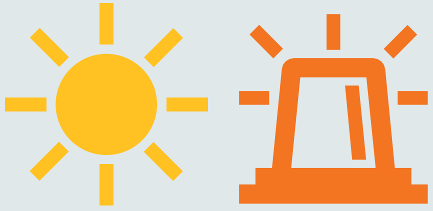
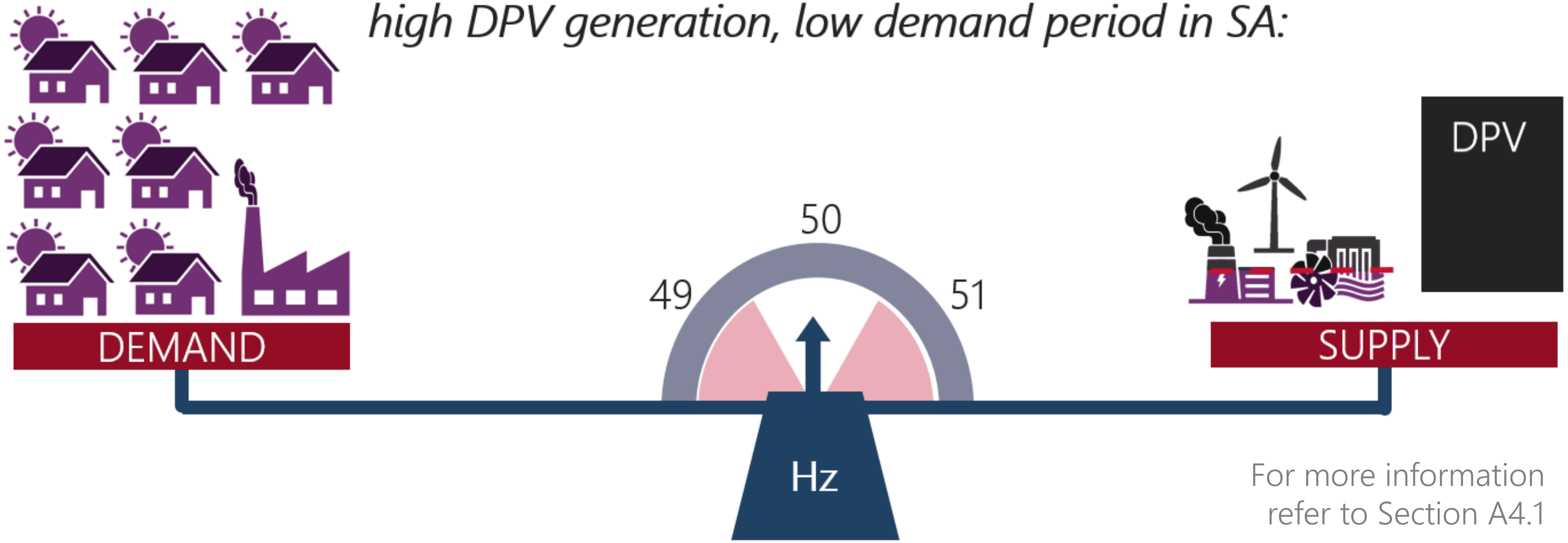
Case study: need for last resort DPV curtailment



Urgent need for **DPV generation curtailment** capability in the South Australia during **extreme abnormal conditions**

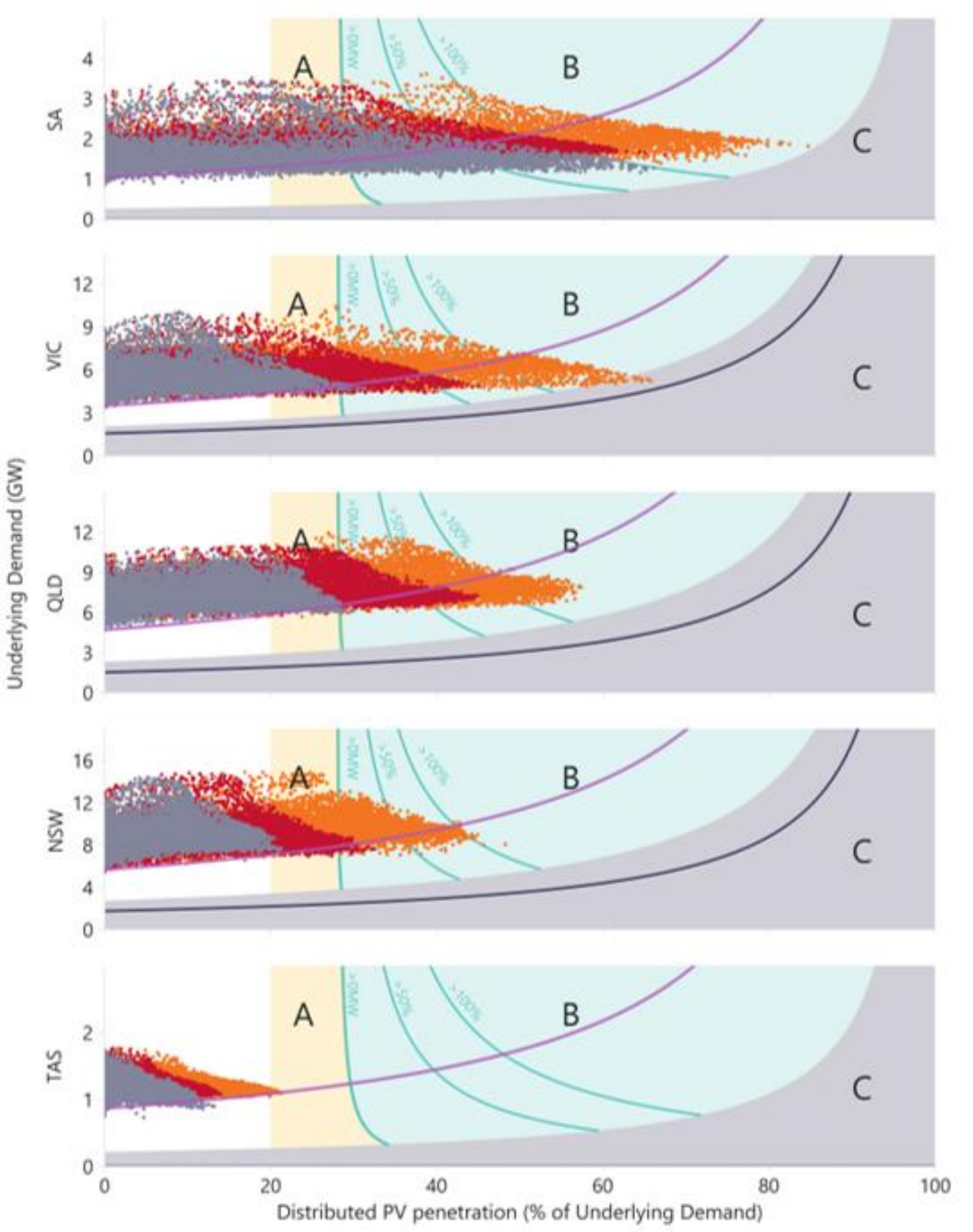
If extreme abnormal system conditions were to occur during a high DPV generation, low demand period in SA:

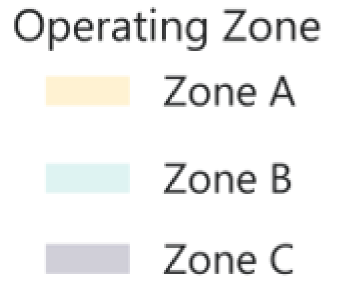


For more information refer to Section A4.1

- Required **exceedingly rarely**
- Change in the **supply-demand balance** could be very large
- Even today, there is **insufficient upward load and storage flexibility**

Bulk system operation out to 2025





- 2019 (Actuals)
- 2025 (ISP Central)
- 2025 (ISP Step Change)

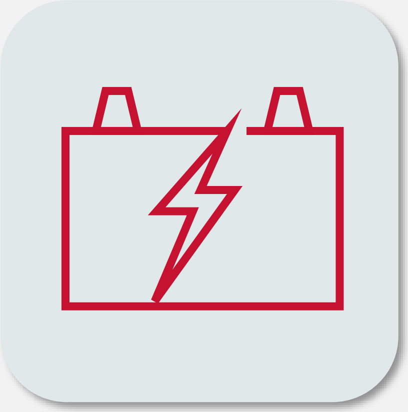
For more information refer to Section A4.4

The full suite of options

A suite of measures can assist with the optimised integration of DPV generation in the future power system.

DPV systems

- Better performance standards
- Active management
- Last resort curtailment



Load and storage

- Active management – 'solar sink'
- Enablement for emergencies

System management

- Reserve availability for abnormal conditions
- Operational constraints on dispatch.

Network development

- Enable balancing across larger area
- Reduce likelihood of islanding

Going forward

Summary of findings

DPV is largely **passive**

Increasing technical challenges to distribution and bulk power system

SA is at the forefront of these challenges

A **suite of measures** is required to **optimise bulk system operation**

Visibility is critical to improving hosting capacity

DNSPs are pursuing **network** and **behind-the-meter measures**

Last resort, backstop mechanisms will still be needed

DPV performance standards

Visibility and ability to curtail DPV

Actions going forward

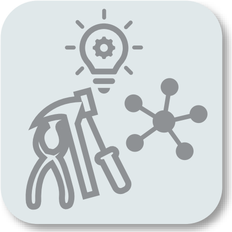
3.1 – 3.3 DPV **performance standards** and **validation**

National inverter standards so networks and operators can work together to ensure **system security**, while maintaining or unlocking **consumer benefits**

3.4 – 3.5 Minimum level of **curtailability** and **visibility**

DPV generation curtailment only during **extreme and rare abnormal conditions**

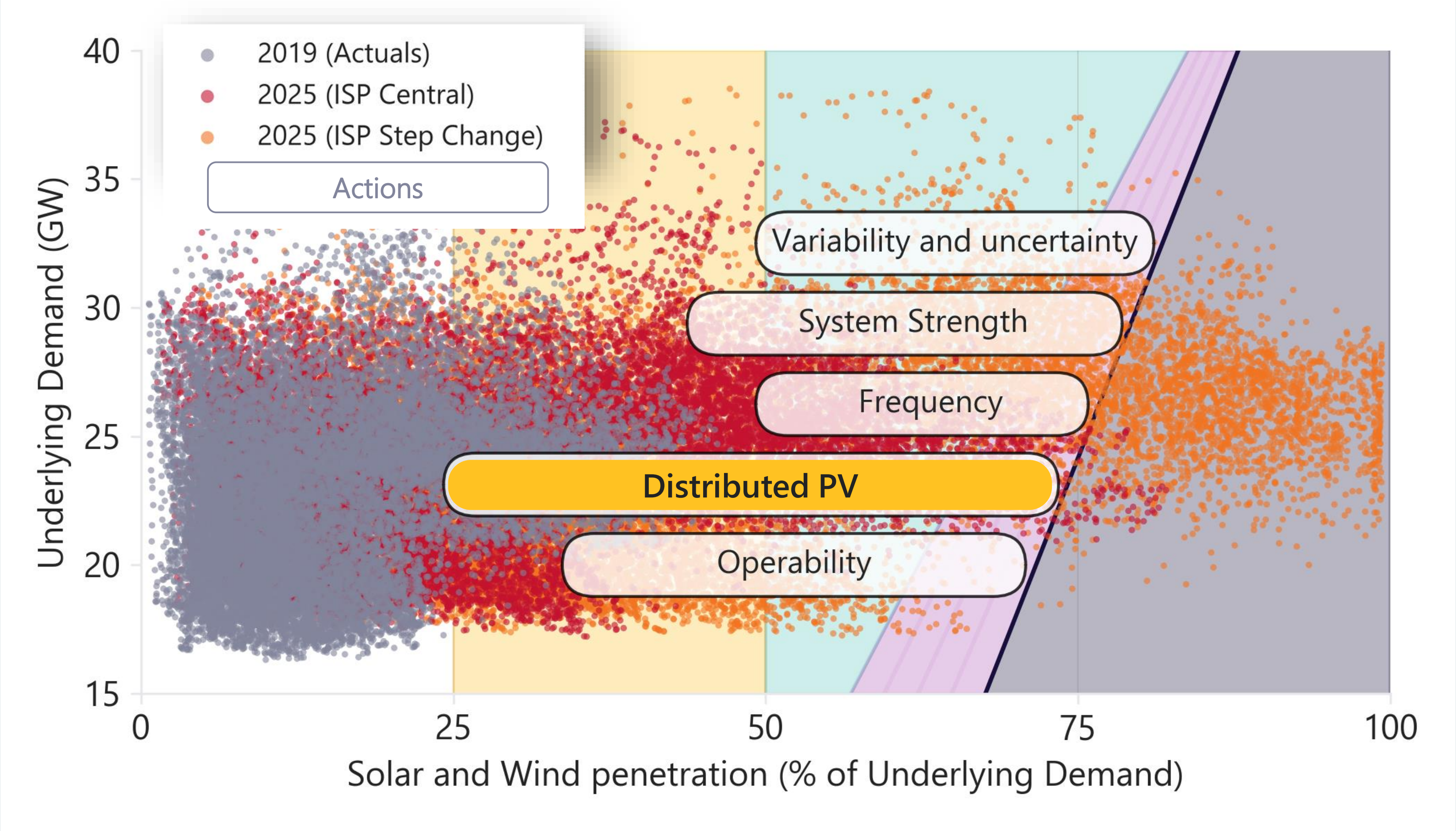
Additional actions (progressing outside of the RIS)



Market and technical enablers for the **efficient optimisation of DPV generation with load and storage** behind the meter.

Measures to **improve visibility and predictability of DPV generation to enable optimisation** in the distribution network and bulk power system.

The big picture



- 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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