Integrating Distributed Energy Resources in Australia

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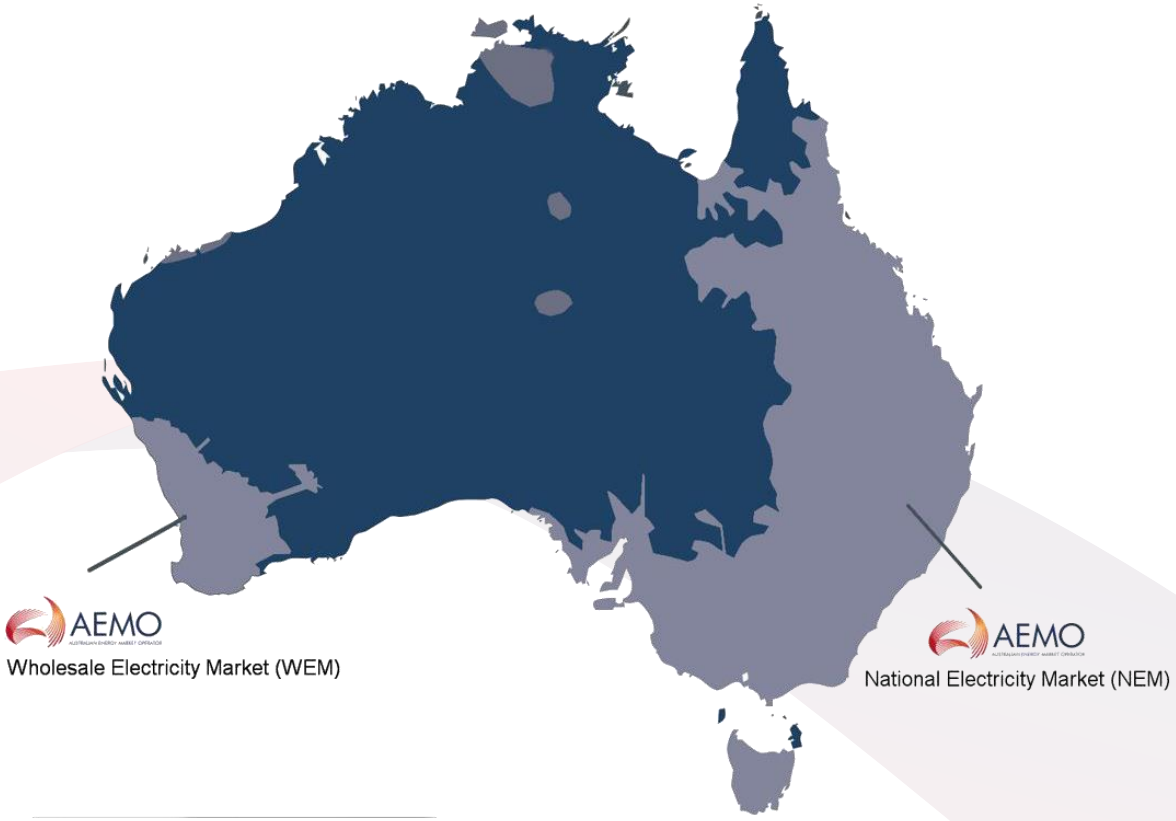
AUSTRALIAN ENERGY MARKET OPERATOR

About AEMO



AEMO is a member-based, not-for-profit organisation.

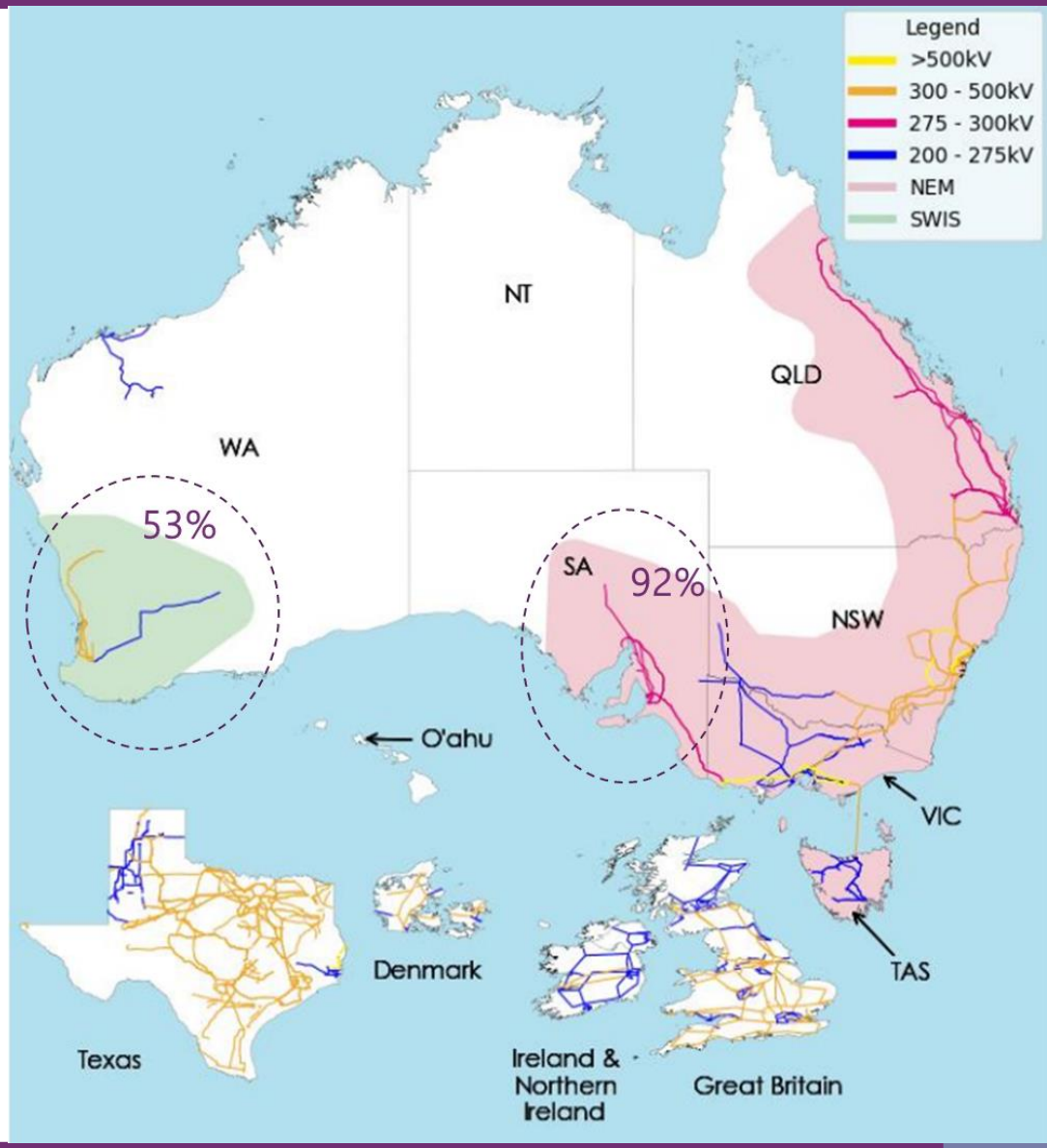
We are the independent energy market and system operator and system planner for the National Electricity Market (NEM) and the WA Wholesale Electricity Market (WEM).

We also operate retail and wholesale gas markets across south-eastern Australia and Victoria's gas pipeline grid.

Distributed PV

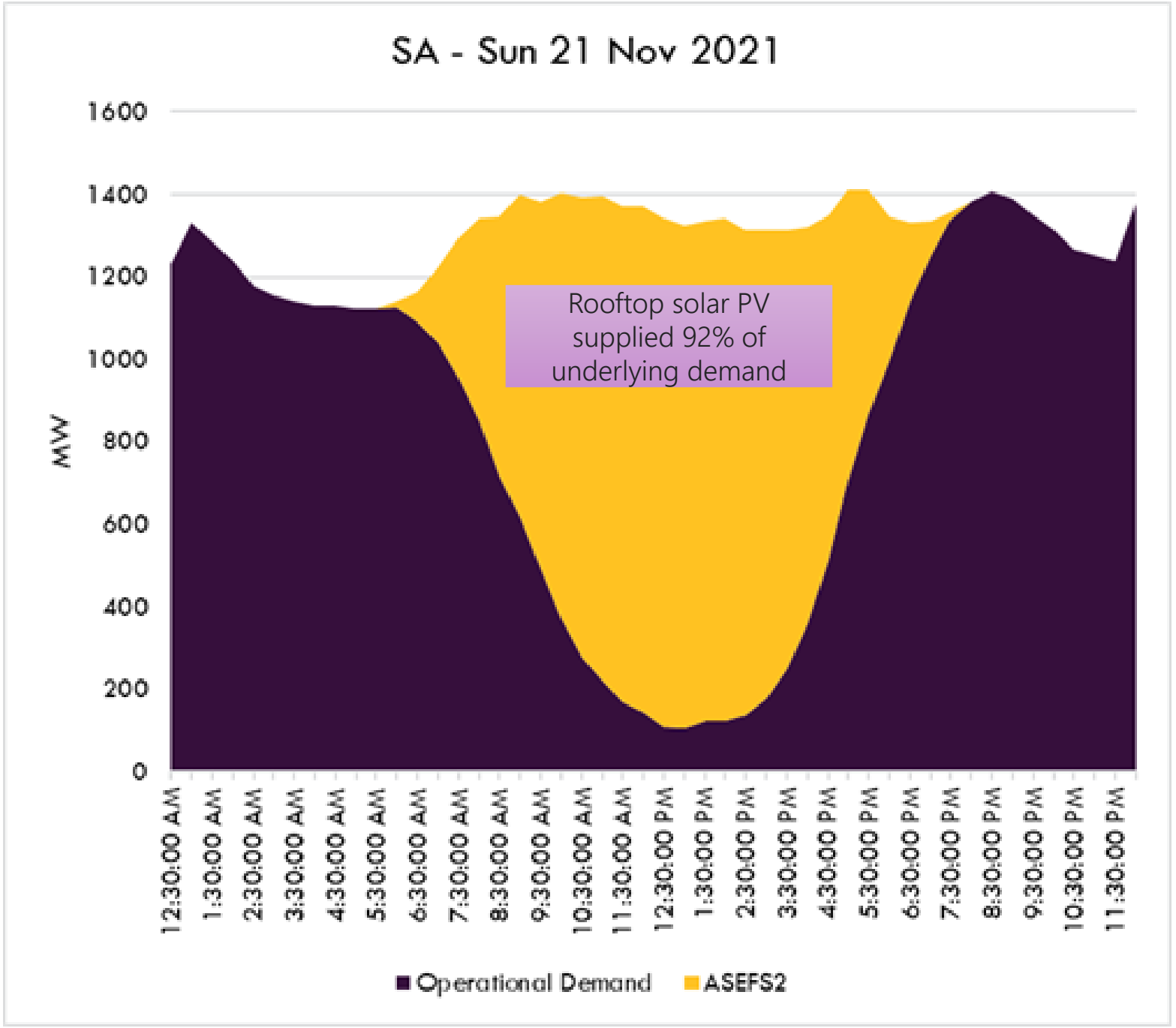
- Significant proportion of demand now met by distributed PV

	Maximum % of underlying load met by distributed PV
SA	92% (2 Oct 2021)
WA	53% (14 Mar 2021)
VIC	47% (31 Oct 2021)
QLD	44% (13 Nov 2021)
NSW	40% (17 Oct 2021)
TAS	14% (26 Oct 2021)



South Australia

- 1.8 GW of distributed PV
- Growing at ~20 MW per month
- Supplying up to 92% of underlying demand
- Minimum operational demand record to date: 104 MW



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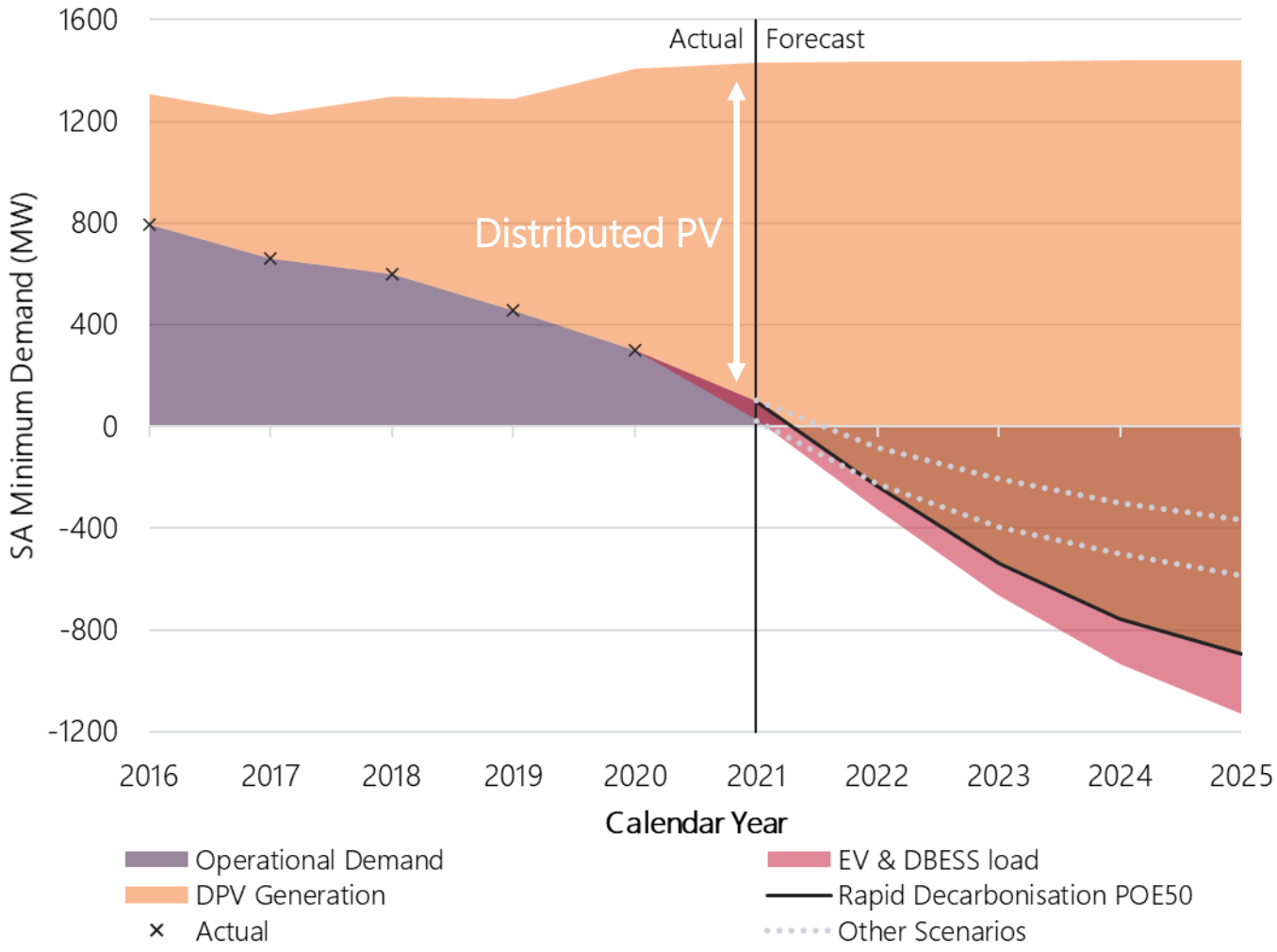
South Australia

- How do we operate a major power grid on only distributed resources?
- What challenges will arise?
- How do we address challenges, removing barriers to growth in distributed resources?

Minimum operational demand in SA:



Challenges identified

Unintended disconnection of distributed PV in disturbances

Insufficient load to operate necessary units for essential services

Under Frequency Load Shedding

- Different but related issues
- Each requires different approaches

Challenge 1: Distributed PV unintended disconnection

- Up to 40% of distributed PV in a region disconnects in response to power system disturbances
- Contingency sizes projected to rapidly become unmanageably large
- Without intervention, AEMO will not be able to maintain the power system in a secure state

AEMO (May 2021) Behaviour of distributed resources during power system disturbances, https://aemo.com.au/-/media/files/initiatives/der/2021/capstone-report.pdf?la=en&hash=BF184AC51804652E268B3117EC12327A

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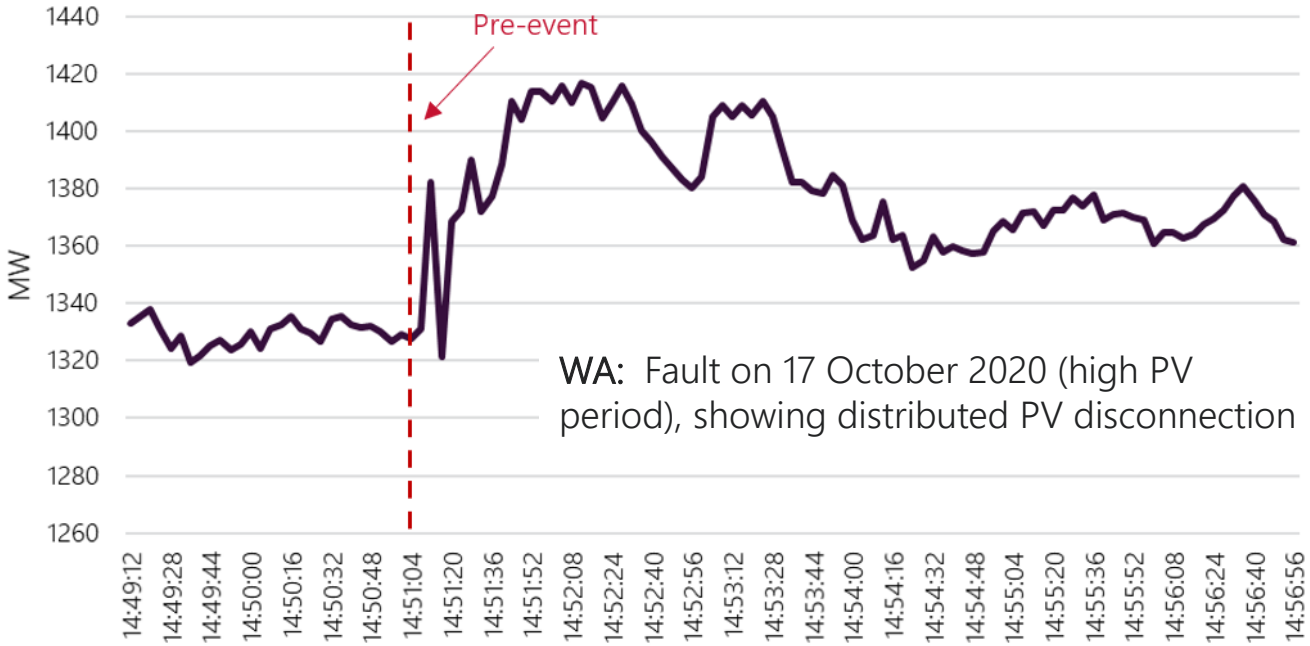
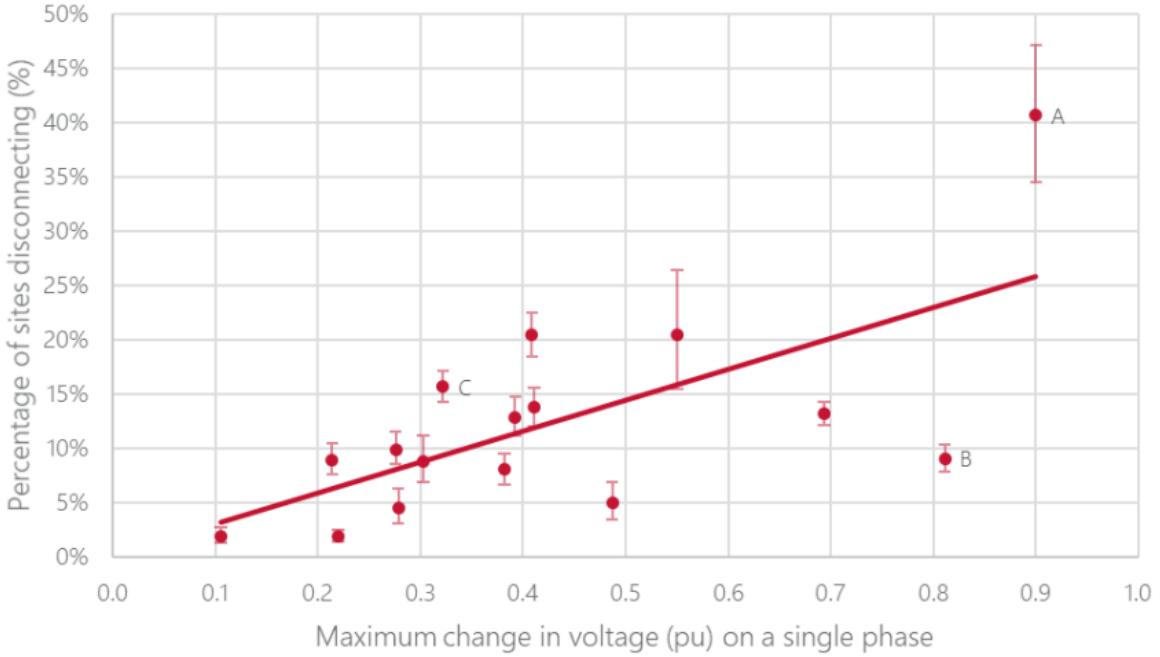


WA: Fault on 17 October 2020 (high PV period), showing distributed PV disconnection

Figure 1 Percentage of DPV sites in a region observed to disconnect following voltage disturbances



Managing DPV unintended disconnections

Improve DER ride-through standards

- Reduce unintended disconnection of future distributed PV installations – "Stop the rot"
- AS/NZS4777.2:2020 mandatory from Dec 2021
- Compliance???
- Will it be sufficient and effective????

Then to manage legacy systems:

Network constraints
- Operate network within stability limits, accounting for larger contingency sizes

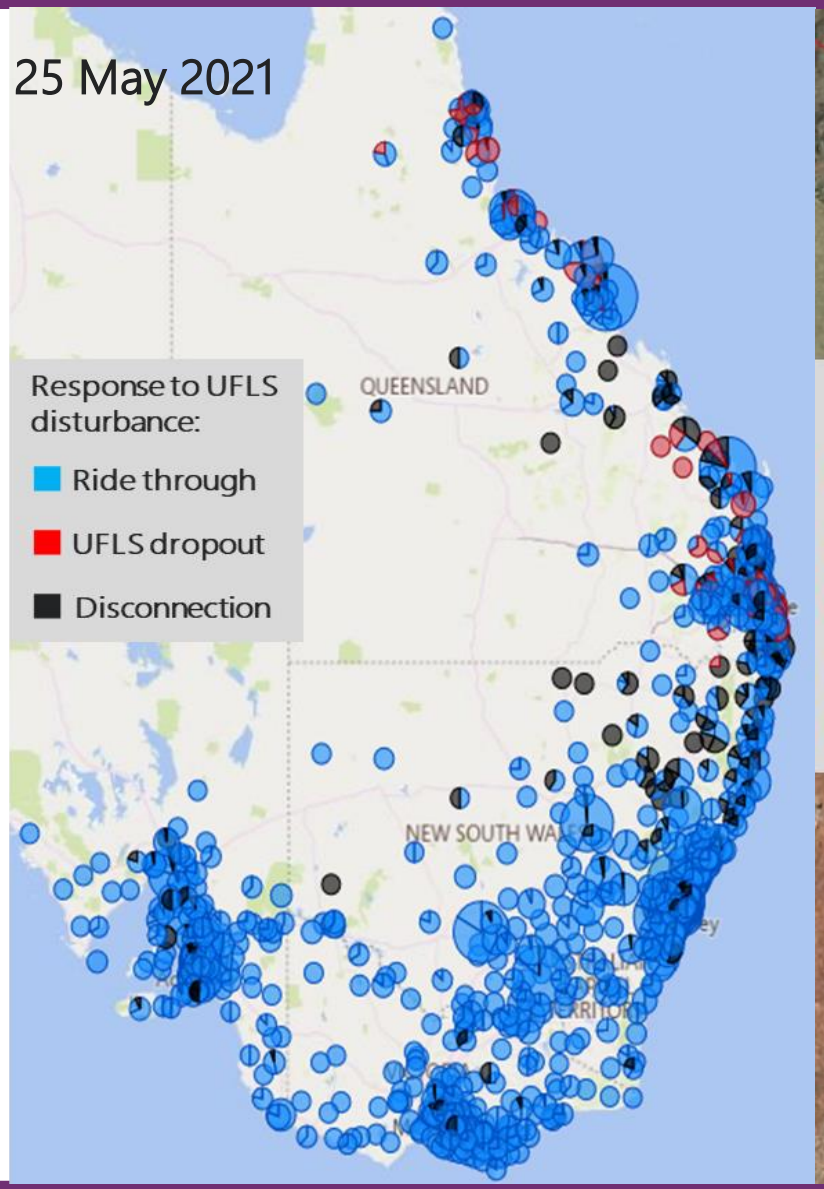
Frequency Control
- Enable sufficient frequency reserves to manage larger contingencies

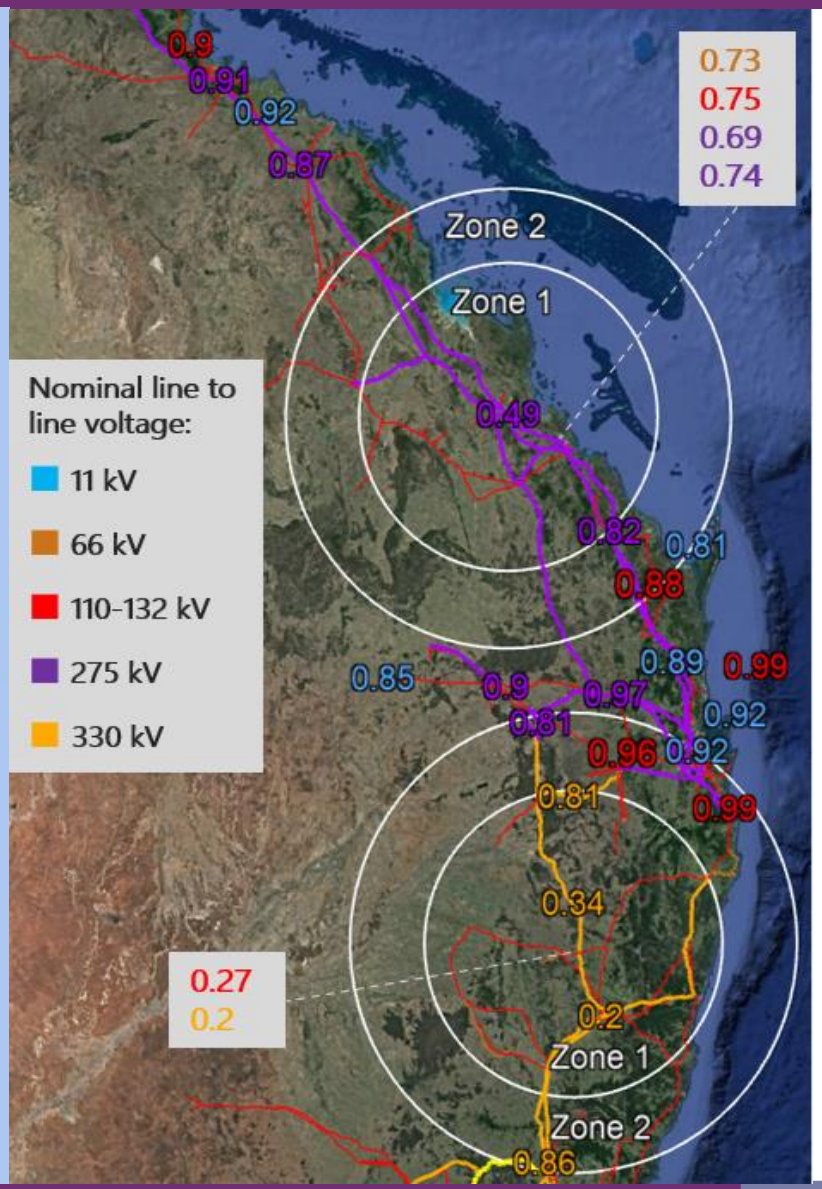
Operating procedures
- Maintain contingency sizes within limits when operating with line outages
- Revoke permission for line outages if need be
- Curtail distributed PV as last resort

Need to accurately estimate distributed PV tripping behaviour

Data!

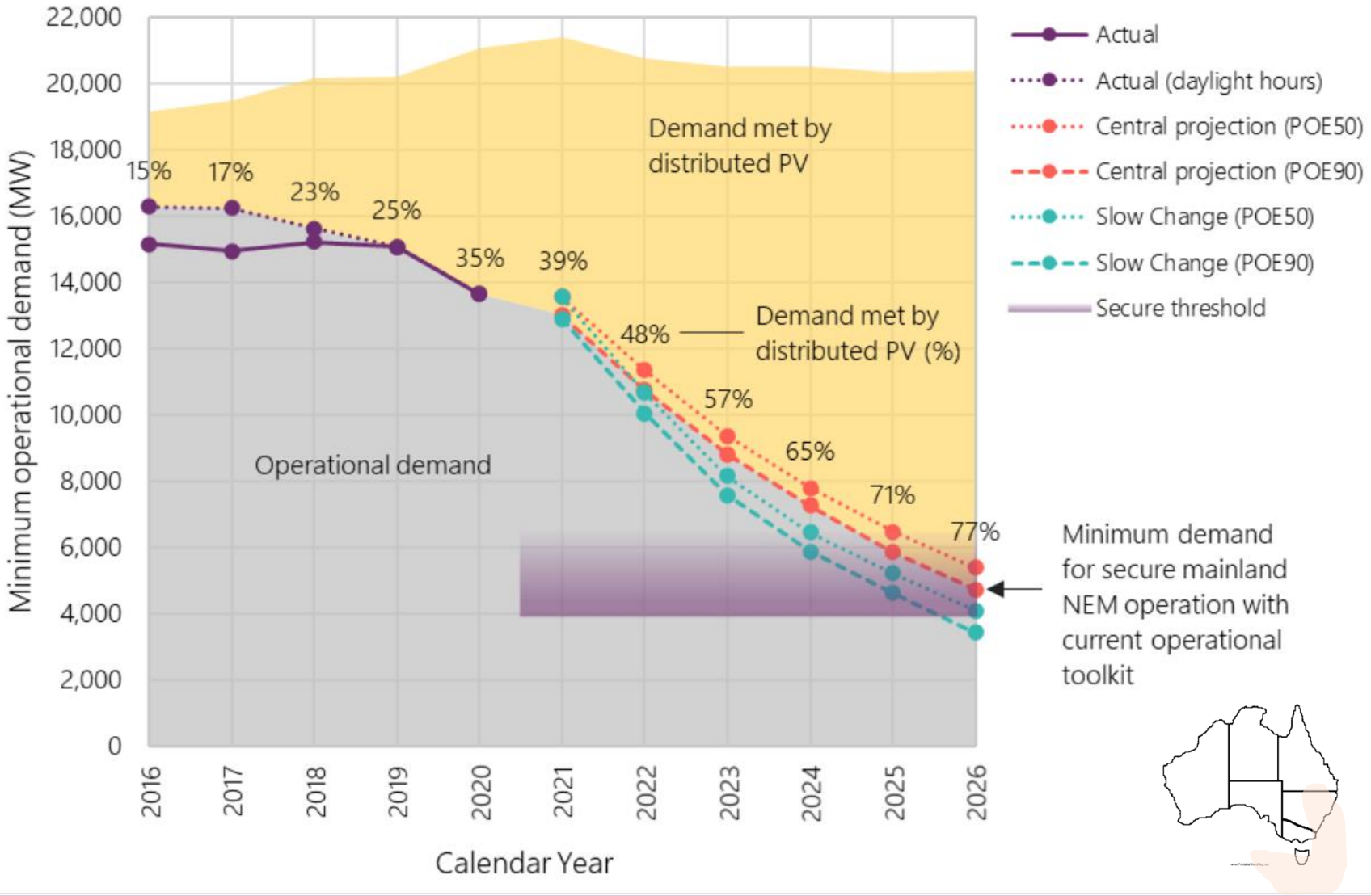
- Significant DER behaviours interacting with grid behaviour
- Cross-matching Solar Analytics datasets with others (Tesla)
- Project MATCH
- Data, data, data!
  - Reduce uncertainty
  - More confidence in intervention measures
  - Reduce need for conservative intervention





AEMO (Oct 2021), Trip of multiple generators and lines in Central Queensland and associated under-frequency load shedding on 25 May 2021, https://aemo.com.au/-/media/files/electricity/nem/market_notices_and_events/power_system_incident_reports/2021/trip-of-multiple-generators-and-lines-in-qld-and-associated-under-frequency-load-shedding.pdf?la=en&hash=F873AE26F7540FCE817AD193BAFD07D9

Challenge 2: Essential power system services



- With present operational toolkit, need to maintain a minimum number of synchronous generating units online at all times to provide essential system services:
  - System strength, inertia, frequency control, voltage control
- These units need to operate above minimum loading levels
- Operational demand is projected to fall below minimum thresholds by 2024 – 2026 for the entire NEM mainland under system normal conditions
- Will reach thresholds sooner during periods with line outages, regions operating as an island, or extreme conditions (e.g. bushfires, storms, explosions, etc.)

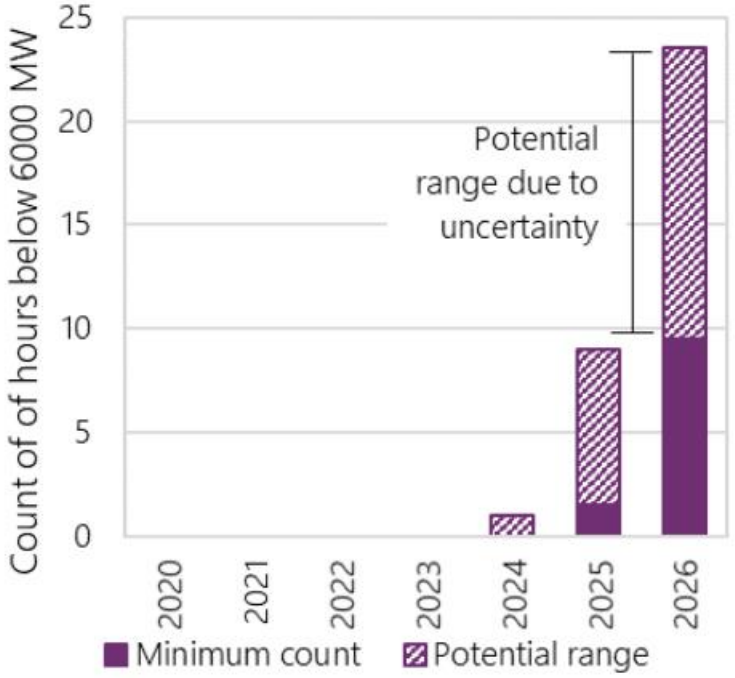
AEMO, ESOO 2021, Section 6.1, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2021/2021-nem-esoo.pdf?la=en&hash=D53ED10E2E0D452C79F97812BDD926ED

Incidence below thresholds

- Demand below thresholds occurs very rarely
- "Perfect Storm" conditions
  - Clear skies
  - Mild weather
  - Low demand (e.g. public holidays, weekends)

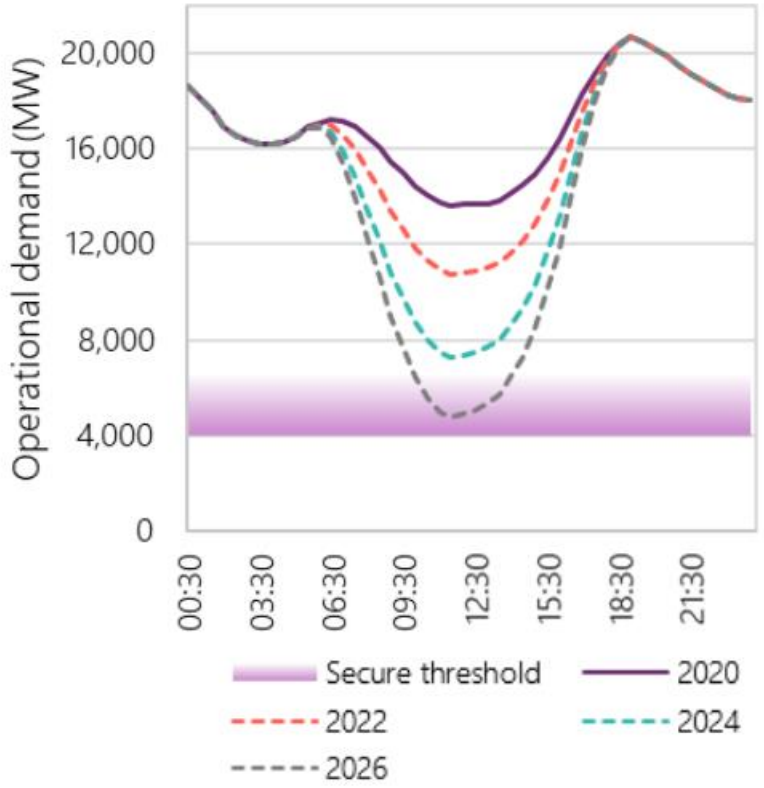
Figure 25 Forecast incidence and duration of operational demand below secure thresholds (NEM mainland)

(a) Indicative range of operational demand below 6,000 MW across central scenario



Multiple simulations with varying POE were run to determine the number of hours in which demand fell below 6,000 MW. This represents a wider spread of possibilities than used in Figure 24.

(b) Example minimum demand day, Central projection 90% POE



AEMO, ESOO 2021, Section 6.1, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2021/2021-nem-esoo.pdf?la=en&hash=D53ED10E2E0D452C79F97812BDD926ED

Emergency backstop PV curtailment

- Introduce emergency capability to curtail distributed PV when required for system security
- Analogous to load shedding
- Used as a last resort, after all other measures have been exhausted
- Anticipate using very rarely
- Can be simple implementation, with more sophisticated capabilities to follow
- In parallel:
  - Explore other ways of providing essential services in minimum demand periods
  - Market development

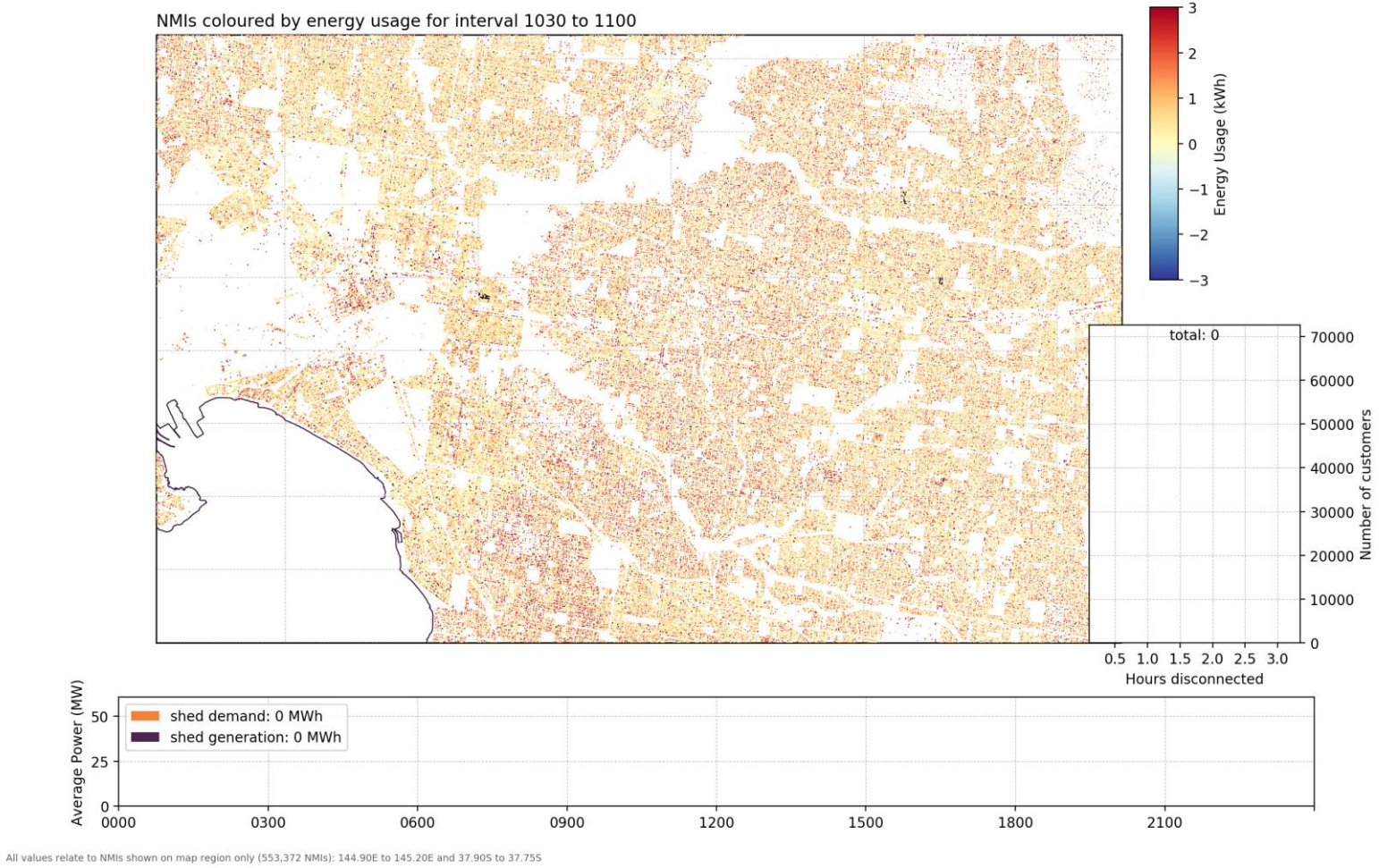
Challenge 3: Under Frequency Load Shedding

- UFLS is the “safety net”, designed to arrest severe under-frequency events
- Controlled disconnection of load in less than a second, to rebalance a large supply-demand imbalance
- Automatic arming of distribution system protection mechanisms

Melbourne Inner East

25 Jan 2019

1030 to 1100



All values relate to NMIs shown on map region only (553,372 NMIs): 144.90E to 145.20E and 37.90S to 37.75S

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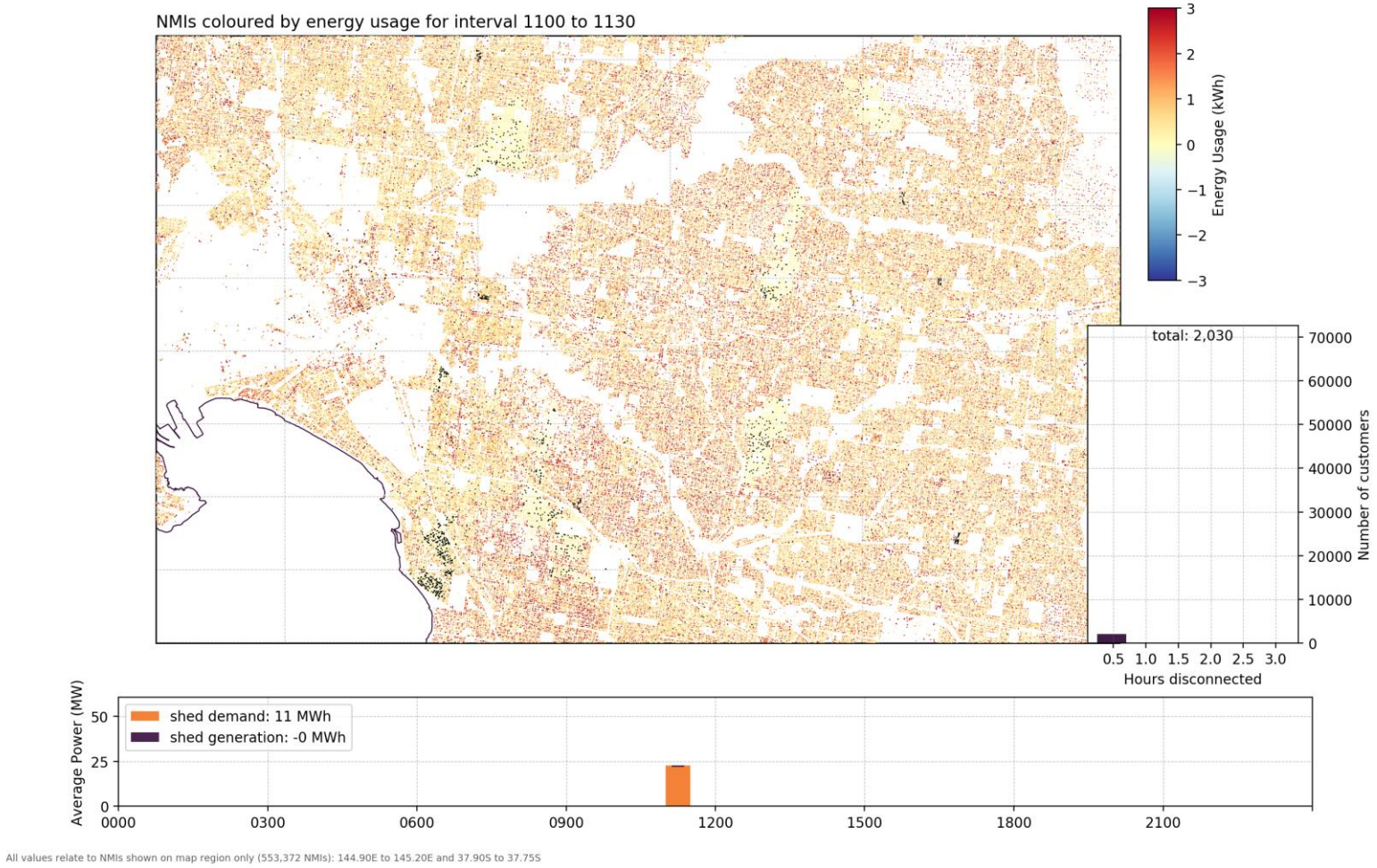
Melbourne Inner East

25 Jan 2019

1100 to 1130



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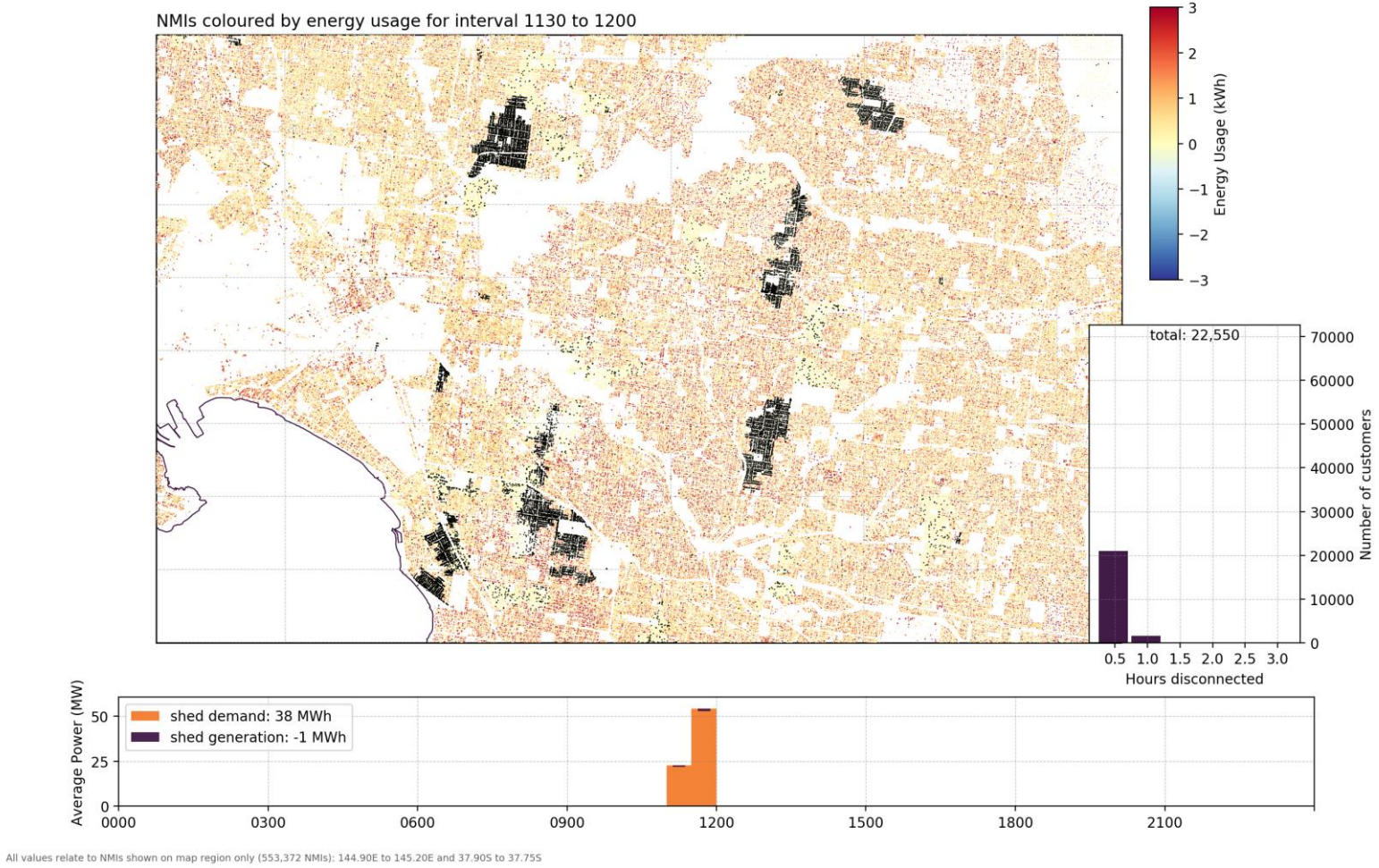
Melbourne Inner East

25 Jan 2019

1130 to 1200



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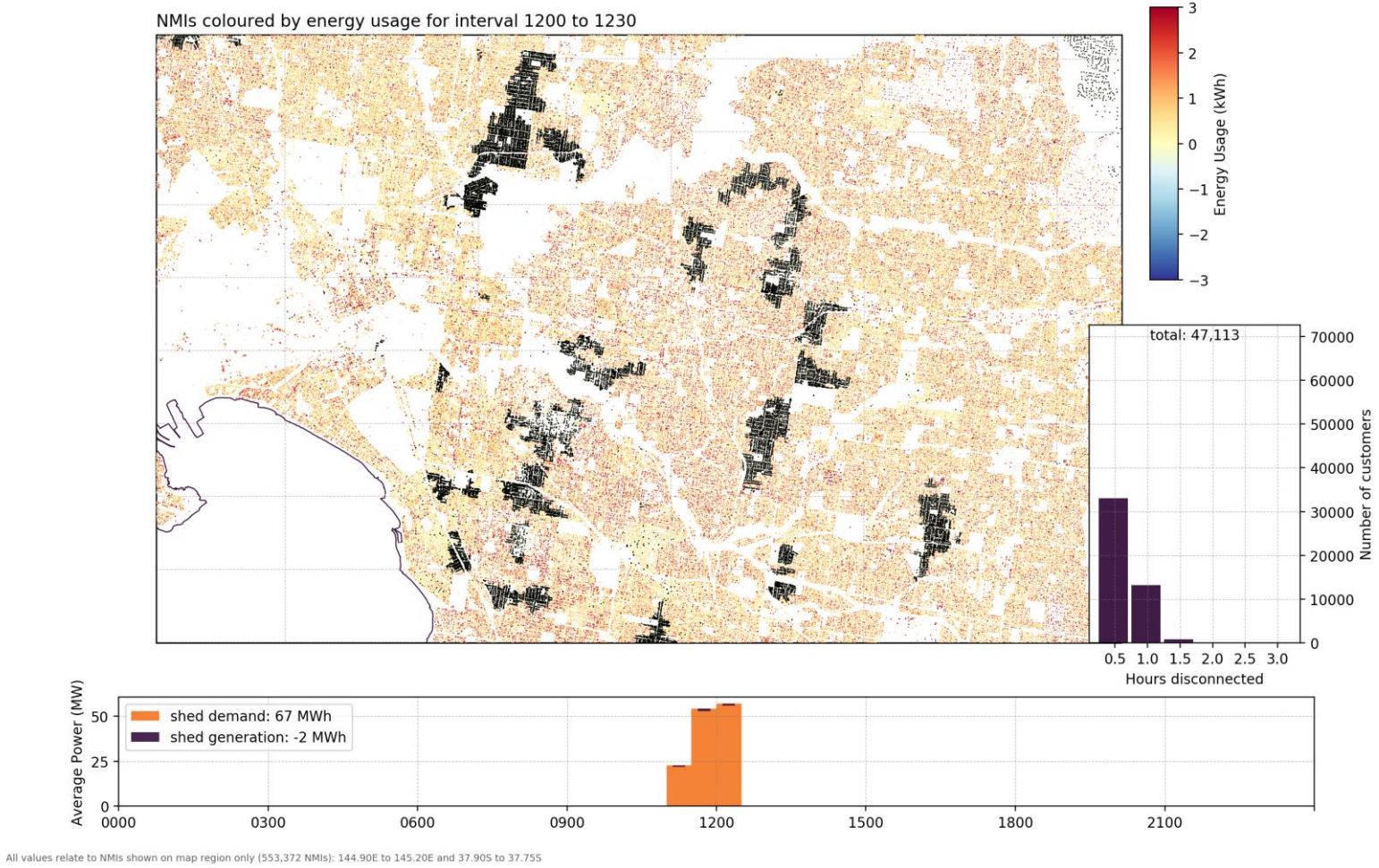
Melbourne Inner East

25 Jan 2019

1200 to 1230



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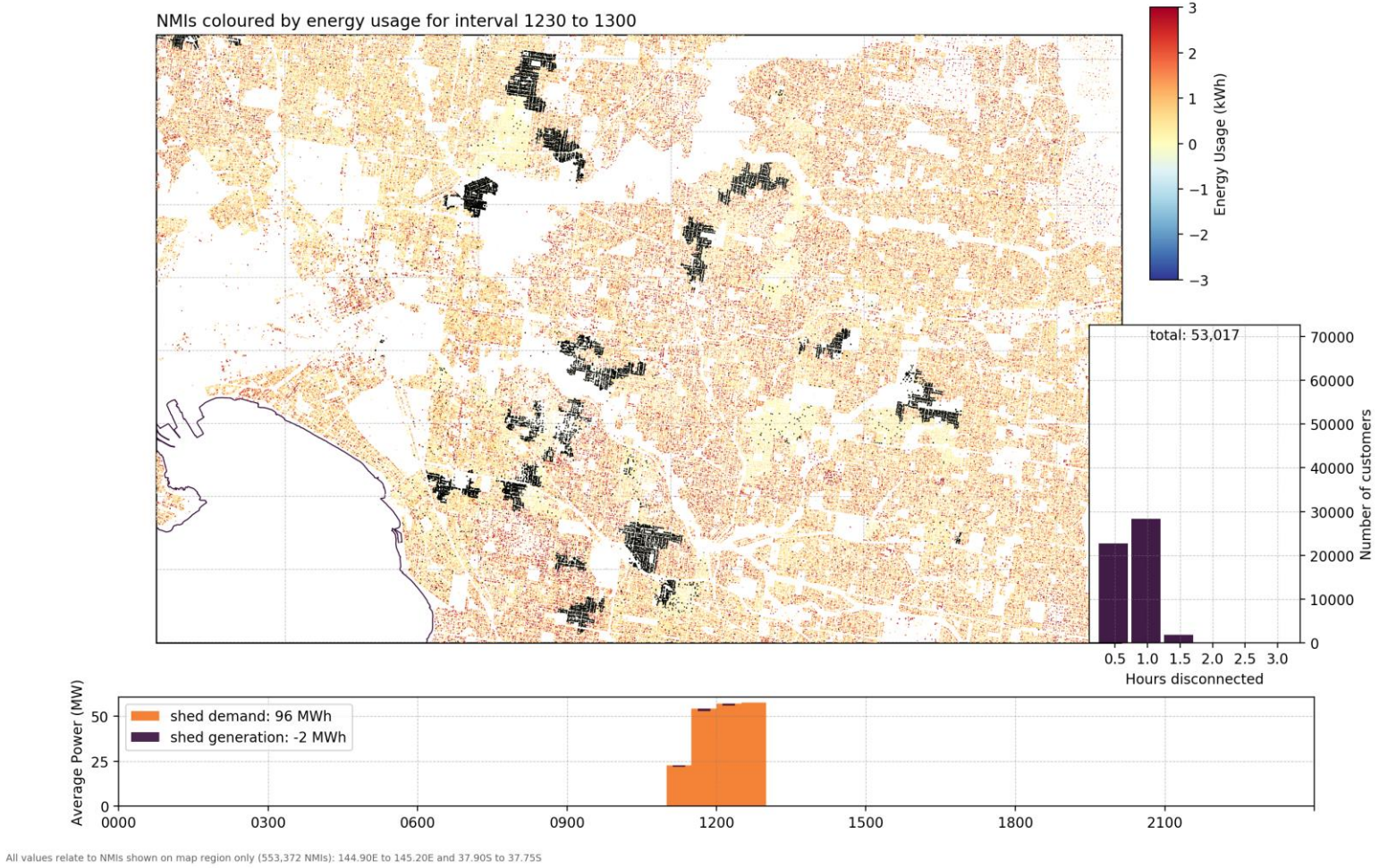
25 Jan 2019

1230 to 1300



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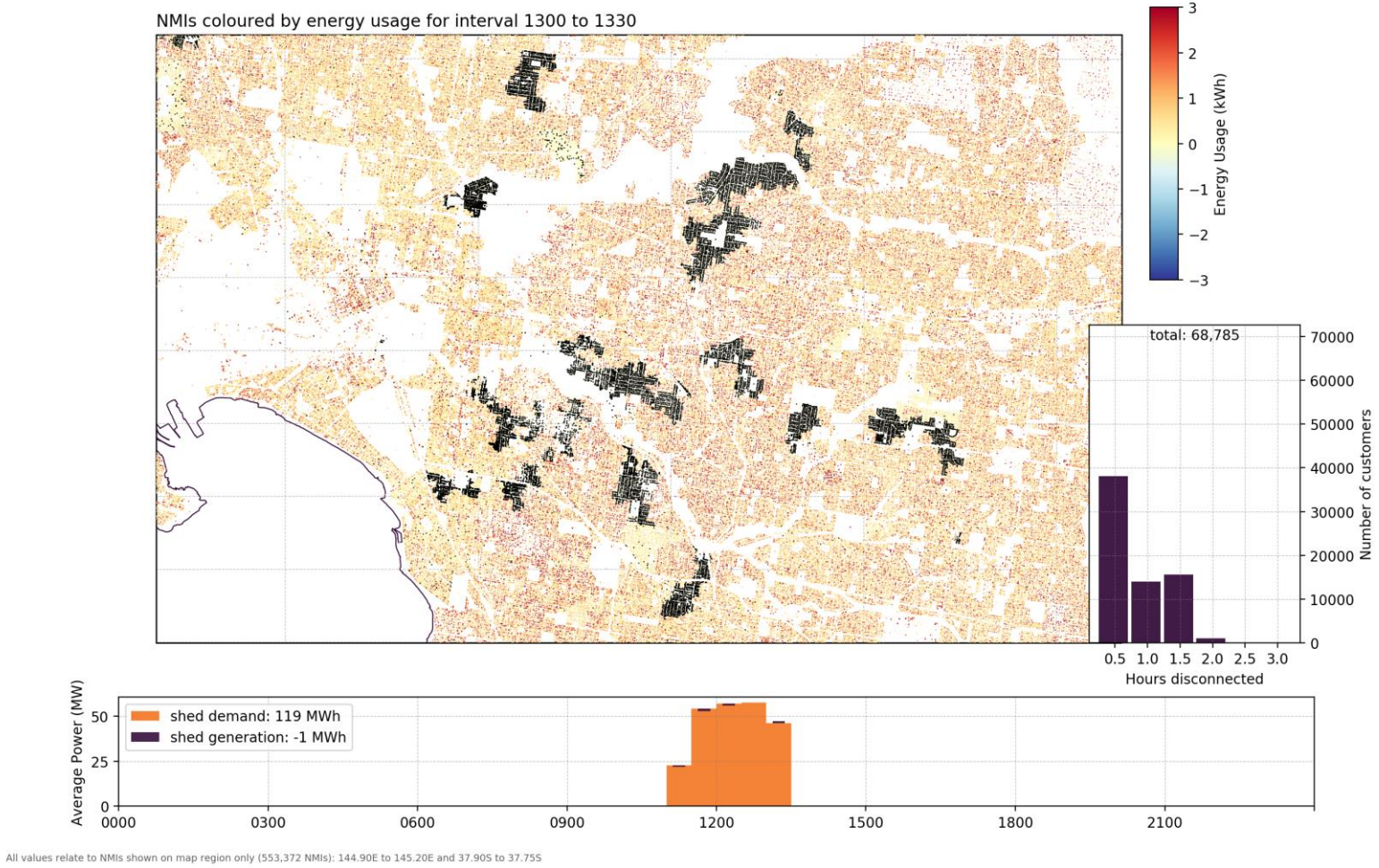
1300 to 1330



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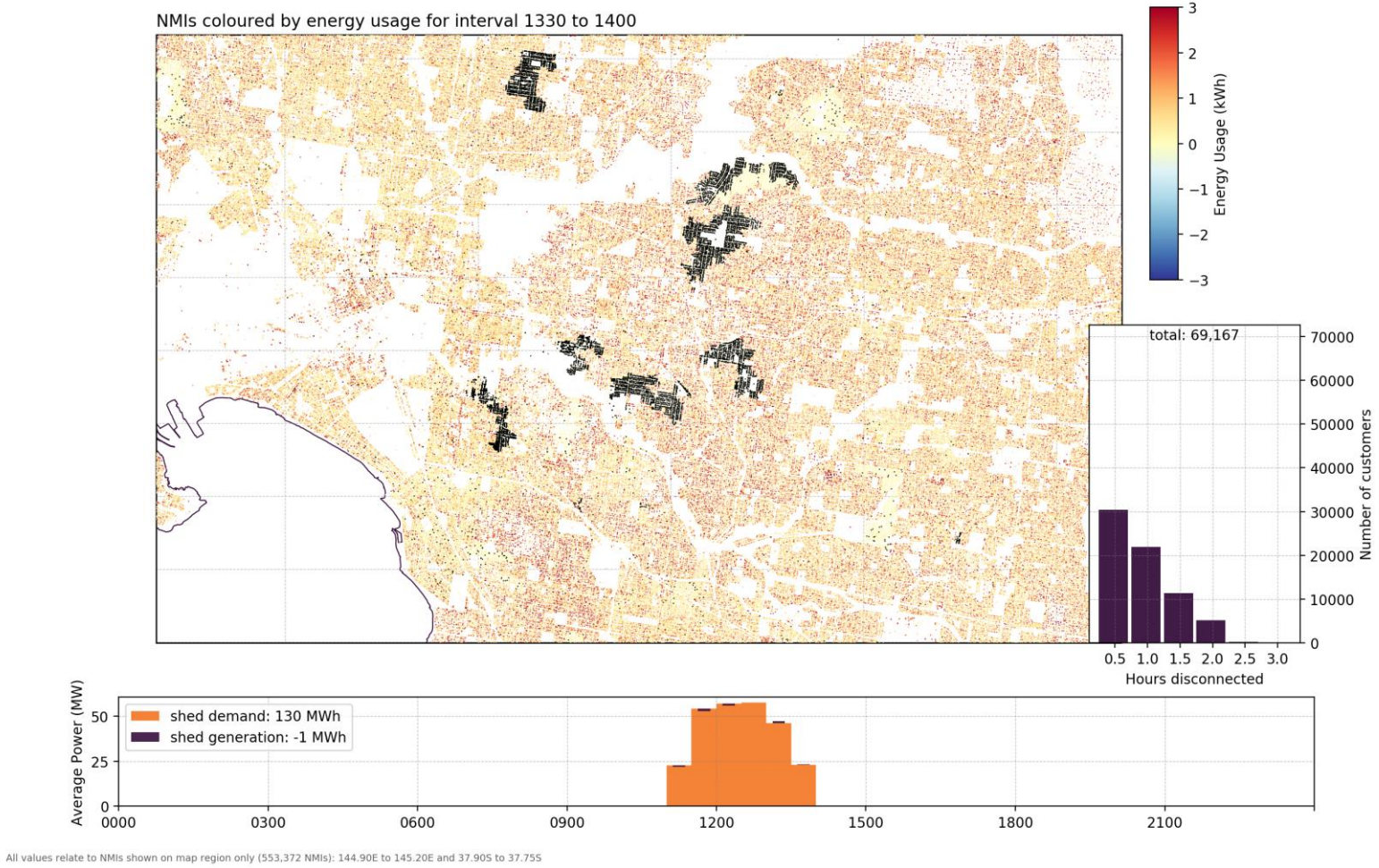
Melbourne Inner East

25 Jan 2019

1330 to 1400



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Melbourne Inner East

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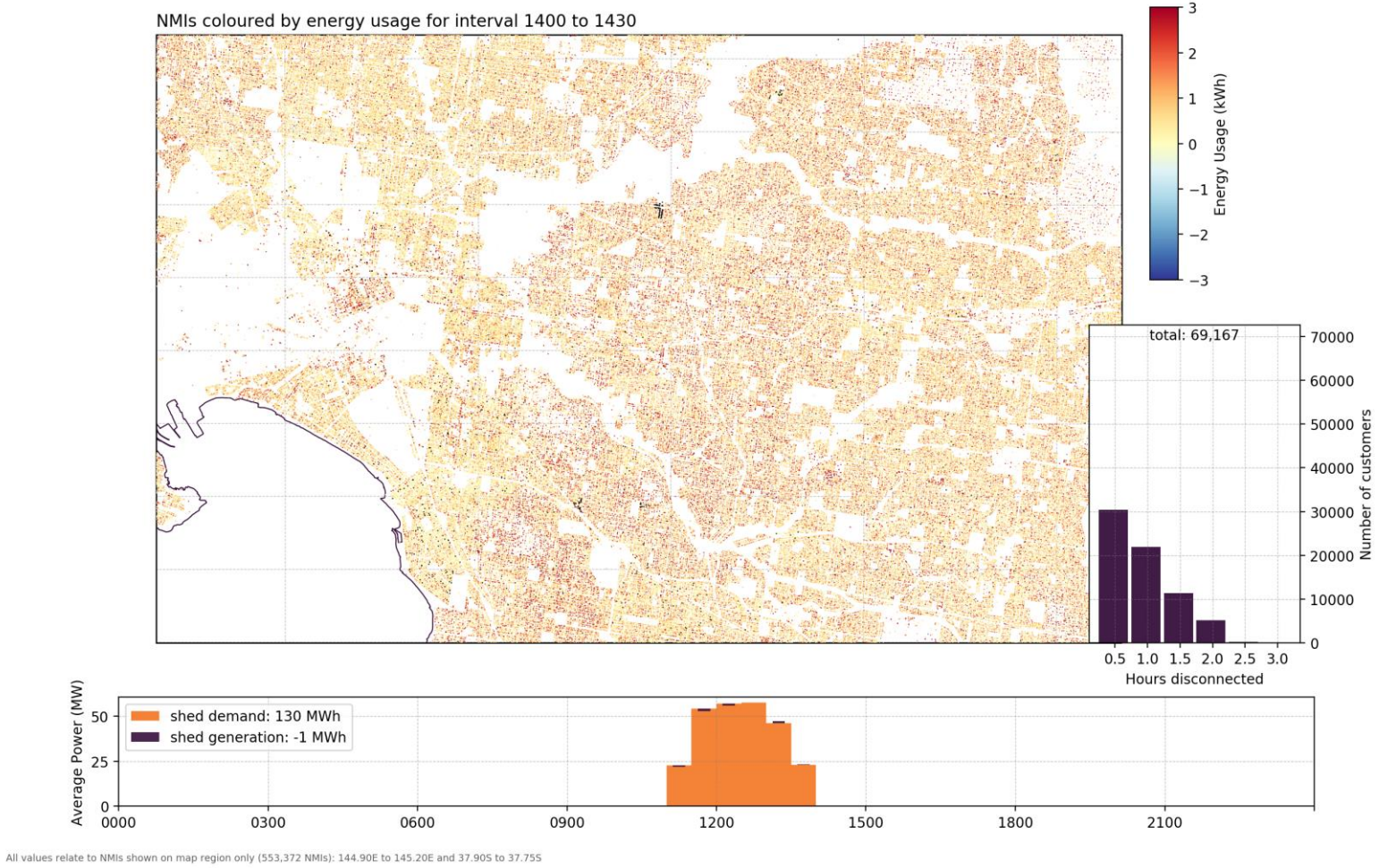
1400 to 1430



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Trials & Demonstrations

Virtual Power Plant Demonstrations & Project EDGE

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VPP objectives

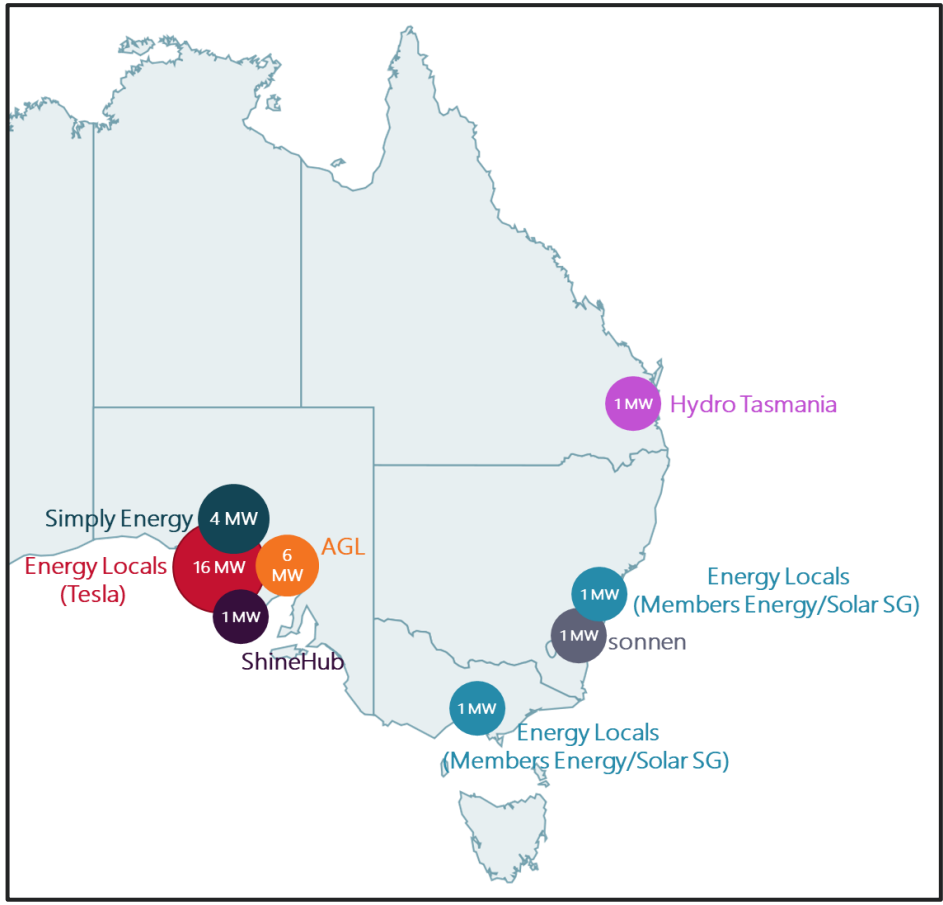
Test VPPs delivering contingency Frequency Control Ancillary Service (FCAS), obtain operational visibility, use learnings to inform changes to regulatory and operational frameworks.

1. Participants **demonstrate basic control and orchestration** capability for VPPs providing real time energy and Frequency Control Ancillary Services (FCAS).
2. Develop systems to deliver **operational visibility of VPPs** via new AEMO APIs.
3. Assess **current regulatory and operational arrangements** affecting market participation of VPPs.
4. Provide insights on how to **improve consumers' experience of VPPs** in future.
5. Understand what **cyber security measures** VPPs currently implement, and whether they should be augmented in future.

VPP Participants, 31MW, all mainland NEM states

	Energy Locals (Tesla SA VPP)	AGL	Simply Energy	sonnen	ShineHub	Energy Locals (Members Energy)	Hydro Tasmania
DUID	VSSEL1V1	VSSAE1V1	VSSSE1V1	VSNSN1V1	VSSSH1S1	VSVEL2S1, VSNEL2S1	VSQHT1V1
Jurisdiction	SA	SA	SA	NSW	SA	VIC and NSW	QLD
Registration *	MC	MC	MC	MASP	MASP	MC	MASP
Battery technology	Tesla PowerWalls	Tesla PowerWalls	Tesla PowerWalls	sonnen	AlphaESS	Alpha ESS Saj/Everready	Tesla PowerPack
FCAS delivery	Proportional	Proportional	Proportional	Proportional	Switched	Switched	Proportional
Registered capacity (Aug 2021)	16 MW All cont FCAS	6 MW All cont. FCAS	4 MW All cont FCAS	1 MW All cont FCAS	1 MW All 6 cont FCAS	1 MW (x2) All 6 cont FCAS, except L6	1 MW All 6 cont FCAS

*Registration types are MC = Market Customer, MASP = Market Ancillary Services Provider



VPP Demos: Key takeaways

- ✓ VPPs have **proven their capability to deliver contingency FCAS** and respond to energy price signals.
- ✓ The VPP sector has grown in size and capability over the last 2 years, is still in early development, but with a material capacity in South Australia
- ✓ AEMO is completing a **DER MASS consultation** to determine the ongoing arrangements for FCAS (including measurement & verification).
- ✓ Consumers' experiences mostly translate into **high levels of satisfaction**;
- ✓ **ESB P2025 emphasises role of aggregators** in future arrangements, including Flexible Traders, and to allow participation in ancillary services
- ✓ VPP Demos aimed to adopt a **collaborative approach** to the integration of an emerging sector – **informing change with evidence – with great feedback**
- ✓ Ongoing **collaboration with industry and development of** operational visibility, forecast-ability and coordination of VPPs will be critical to ensuring efficient integration into the power system.

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Project EDGE interactions with DER Implementation Plan

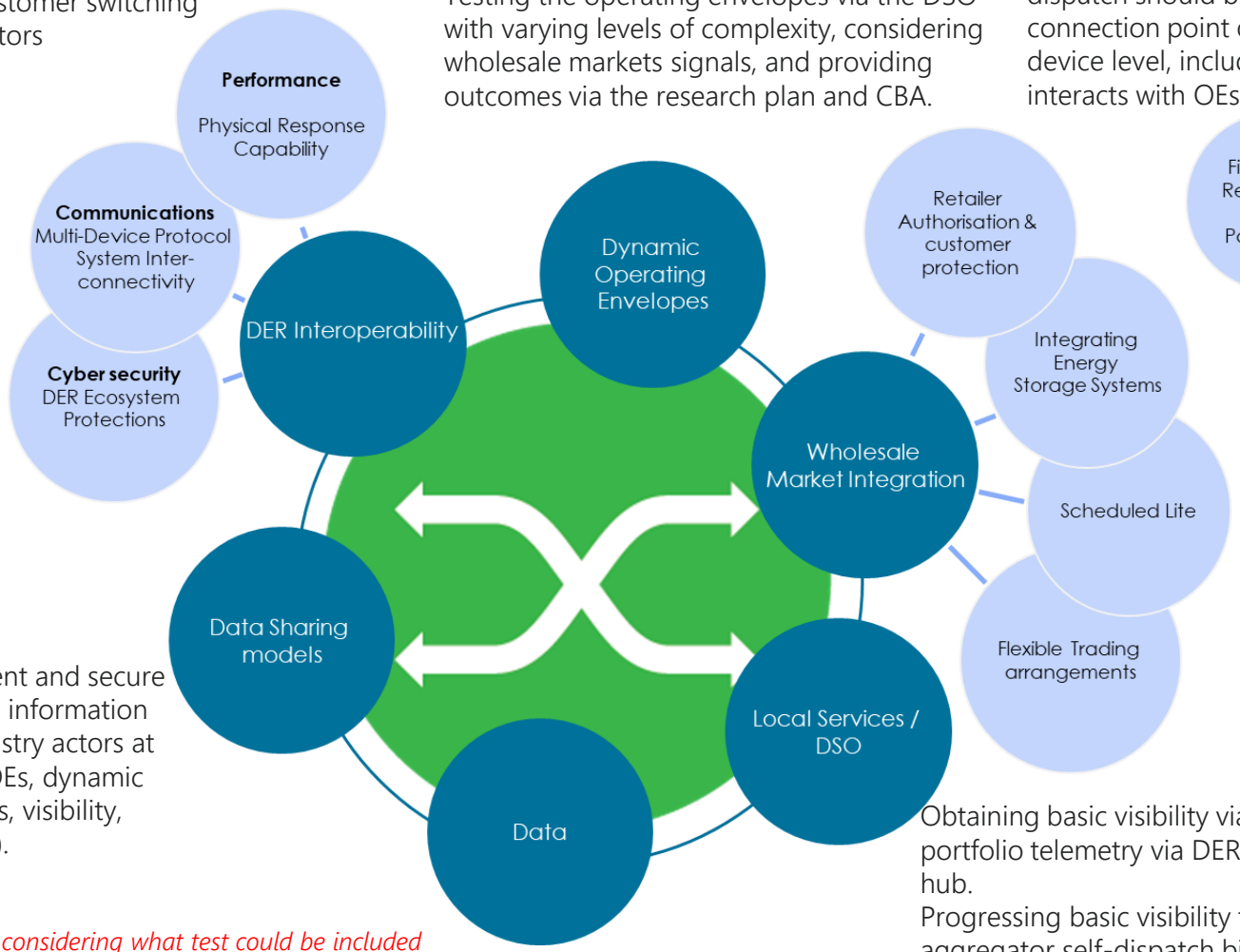
The exploration of aggregator to device standards is out of scope for EDGE.
ESB/DEIP Interoperability objectives:

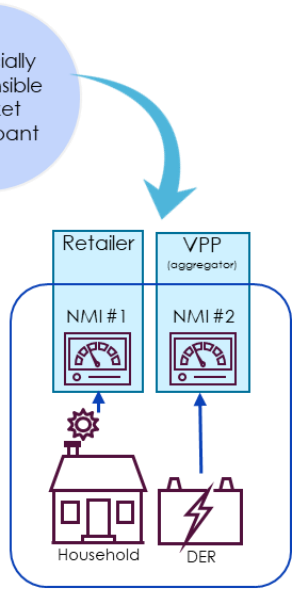
- Enable ease of customer switching between aggregators
- Functionality for consumer, markets & operational requirements

Examining the cyber security risks and requirements throughout the information architecture to support a DER marketplace.

Testing the operating envelopes via the DSO with varying levels of complexity, considering wholesale markets signals, and providing outcomes via the research plan and CBA.

Utilising the dispatchability ★ model aligning with FTA, testing whether the quantity used in dispatch should be at the connection point or controllable device level, including how this interacts with OEs.





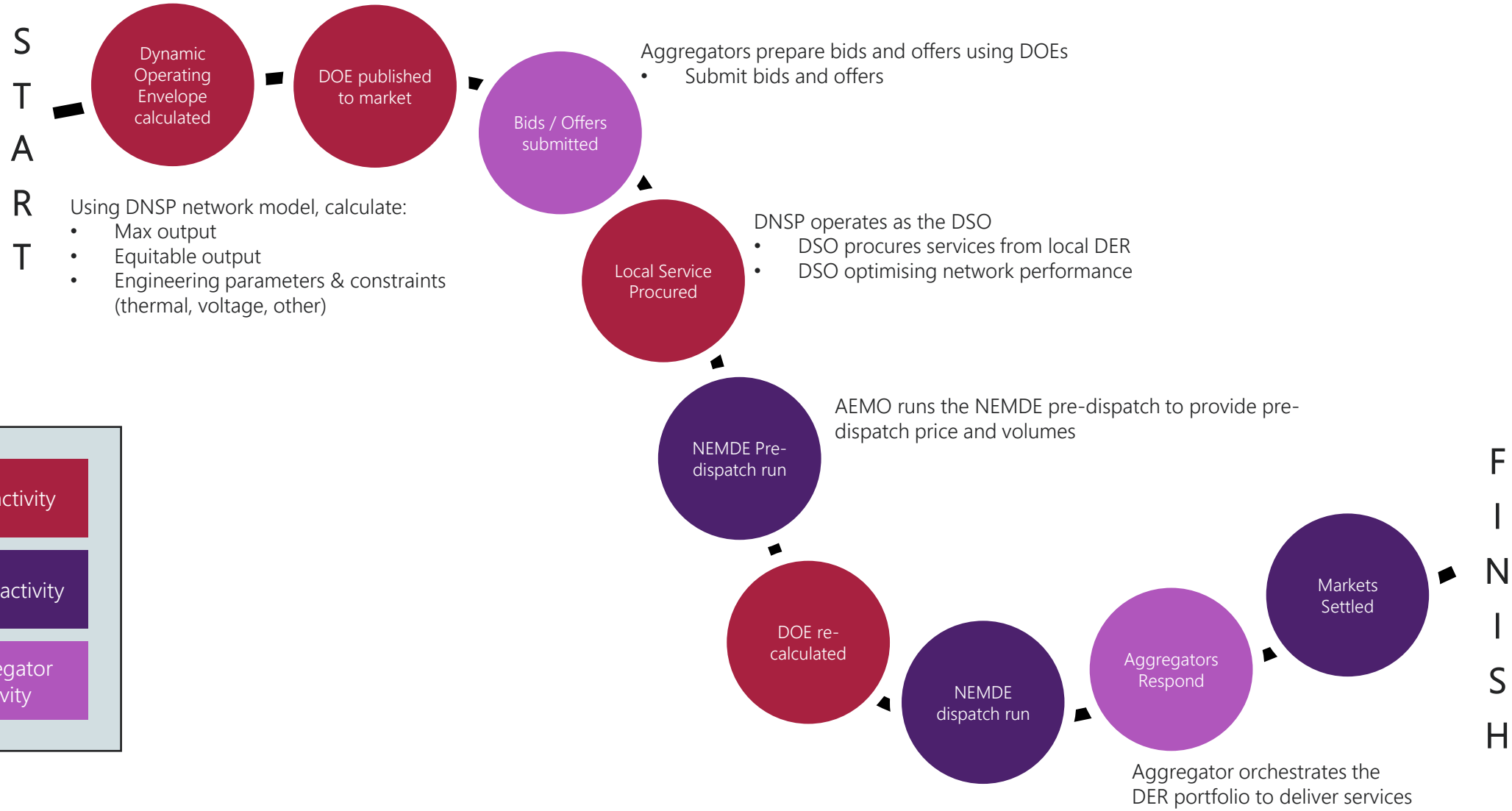
Understanding the perception of consumers and experience pre, during and post participation.

Testing efficient and secure ways to share information between industry actors at scale (e.g. DOEs, dynamic network tariffs, visibility, portfolio info).

Obtaining basic visibility via real-time portfolio telemetry via DER marketplace data hub.
Progressing basic visibility to forecasting via aggregator self-dispatch bid files.

★ *Not in scope but considering what test could be included*

Project EDGE Marketplace Process



Questions?

For more information
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