Distributed Energy Resources: Maximising customer value

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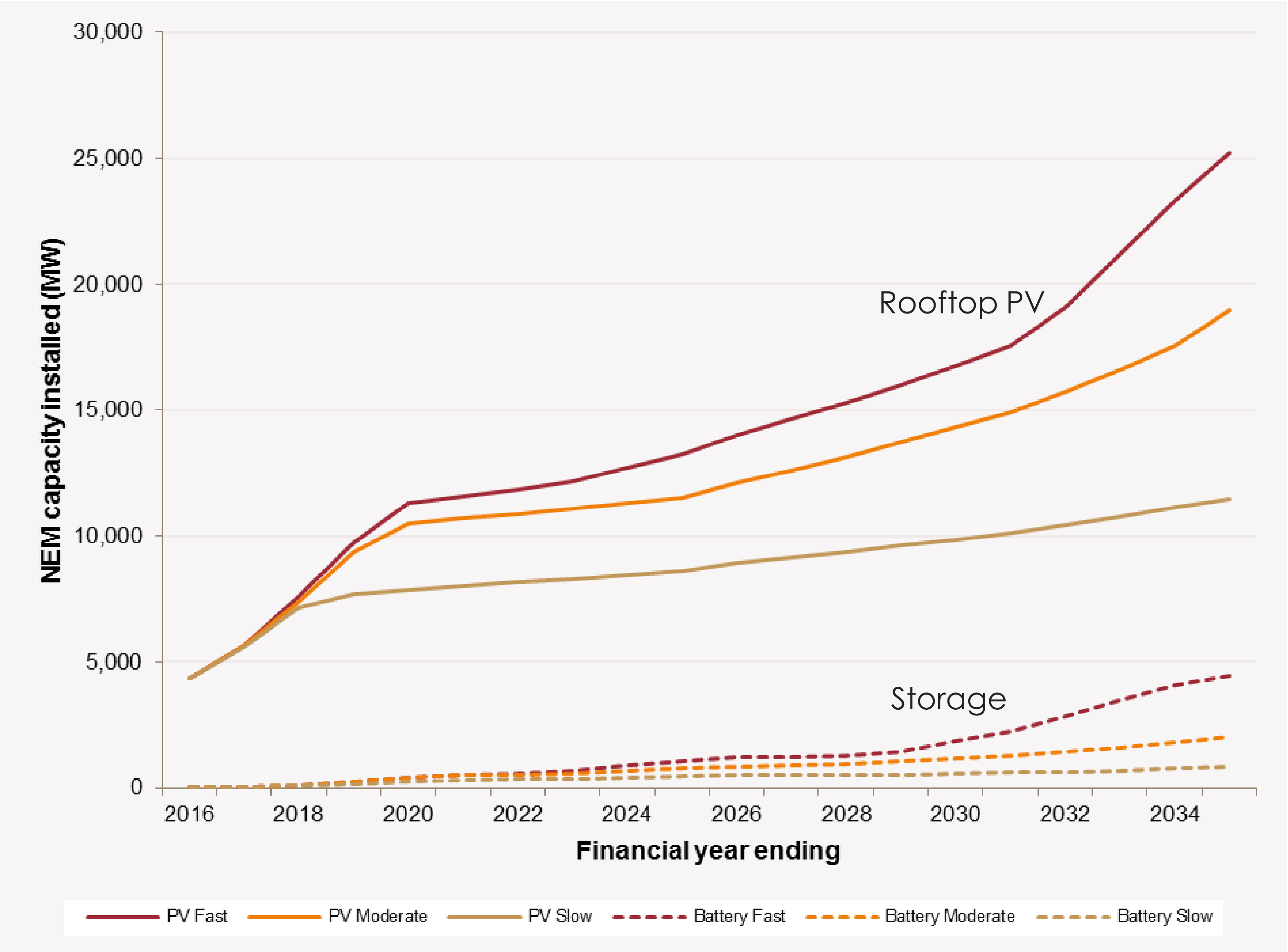
Growth in DER

- Distributed Energy Resources (DER) are growing rapidly
- To access DER opportunities, we need to make sure the power system is secure and reliable
- The transition to decentralised resources could represent the most significant power system transformation since it was established

AEMO's forecast for the NEM:



- What will DER mean for the power system?
- How do we affordably maintain security and reliability for customers throughout this transition to DER?
- What actions do we need to take?
- Identify challenges so they can be addressed, enabling customers to achieve maximum value from their DER

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Power System Requirements

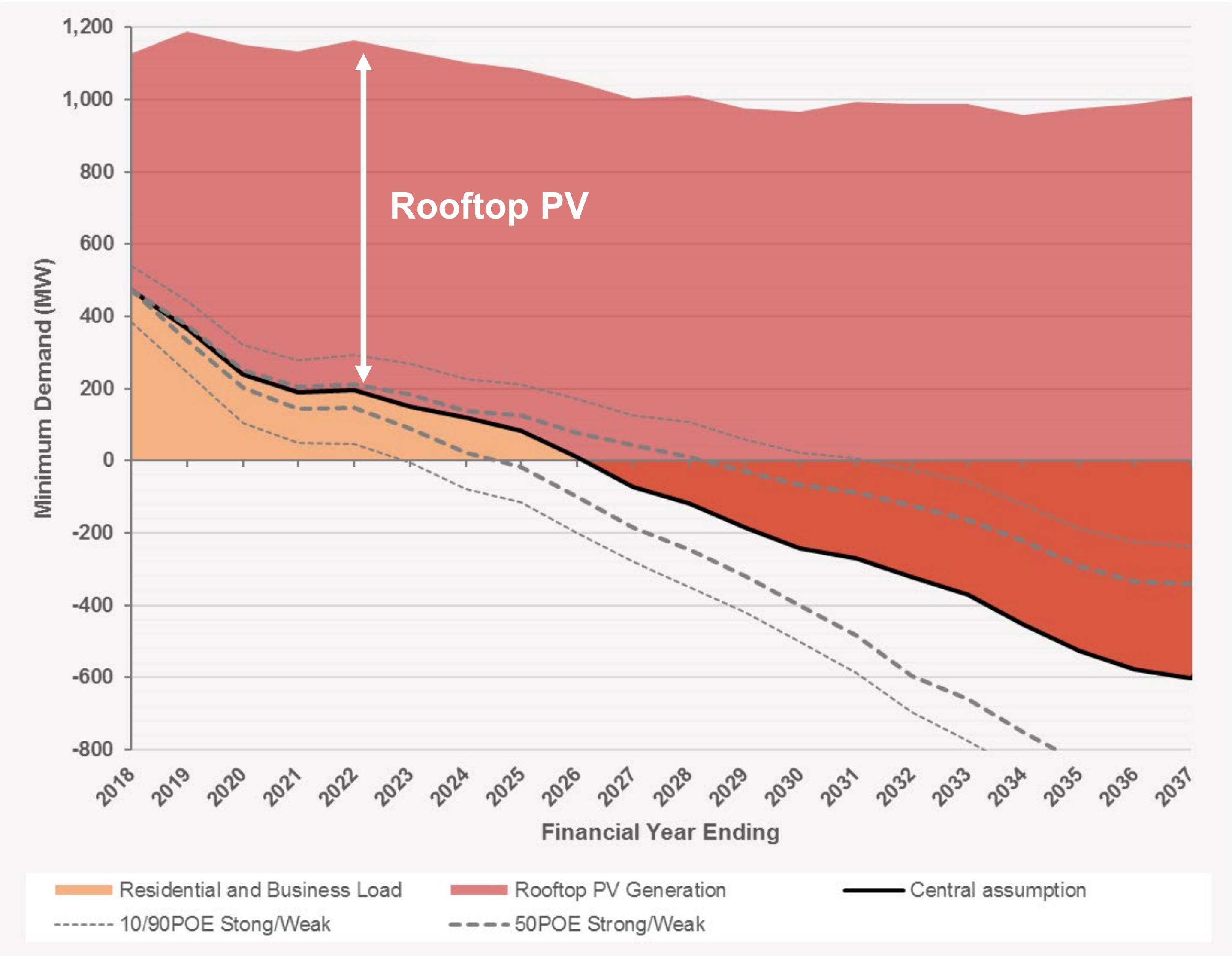
Summarises the technical and operational needs of the power system.

Provides a foundation for exploring power system impacts, and identifying emerging challenges.

Dispatchability

Dispatchability

Minimum demand in South Australia:



By as early as 2023, passive rooftop PV could supply all demand in South Australia in some periods

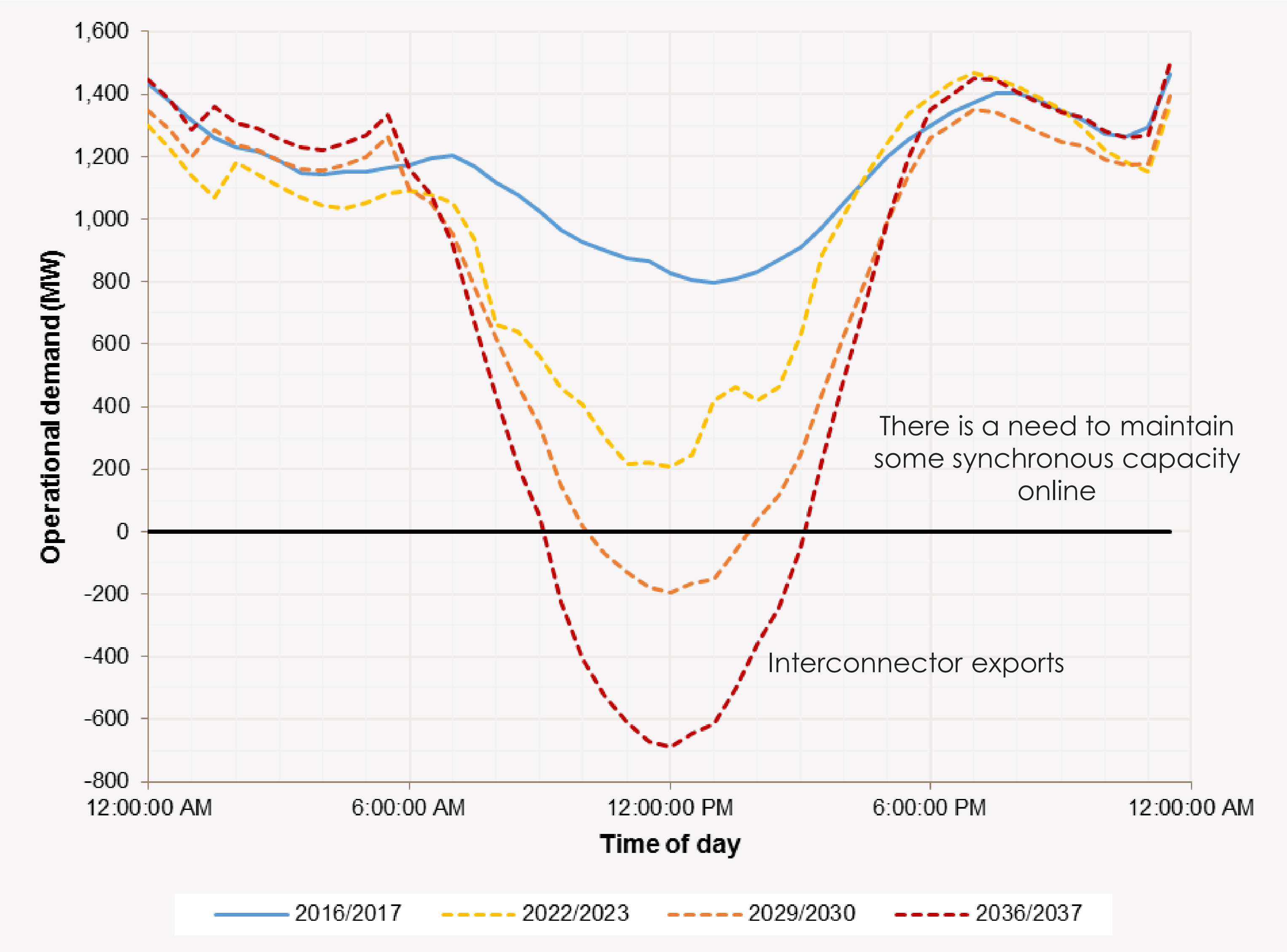
Dispatchability

During the next decade, challenges are mostly associated with operation during "emergency conditions" (bushfires, severe weather, network outages), when flows on the network must be reduced to remain secure. This occurs rarely.

At present, there is no mechanism implemented for active management of rooftop PV.

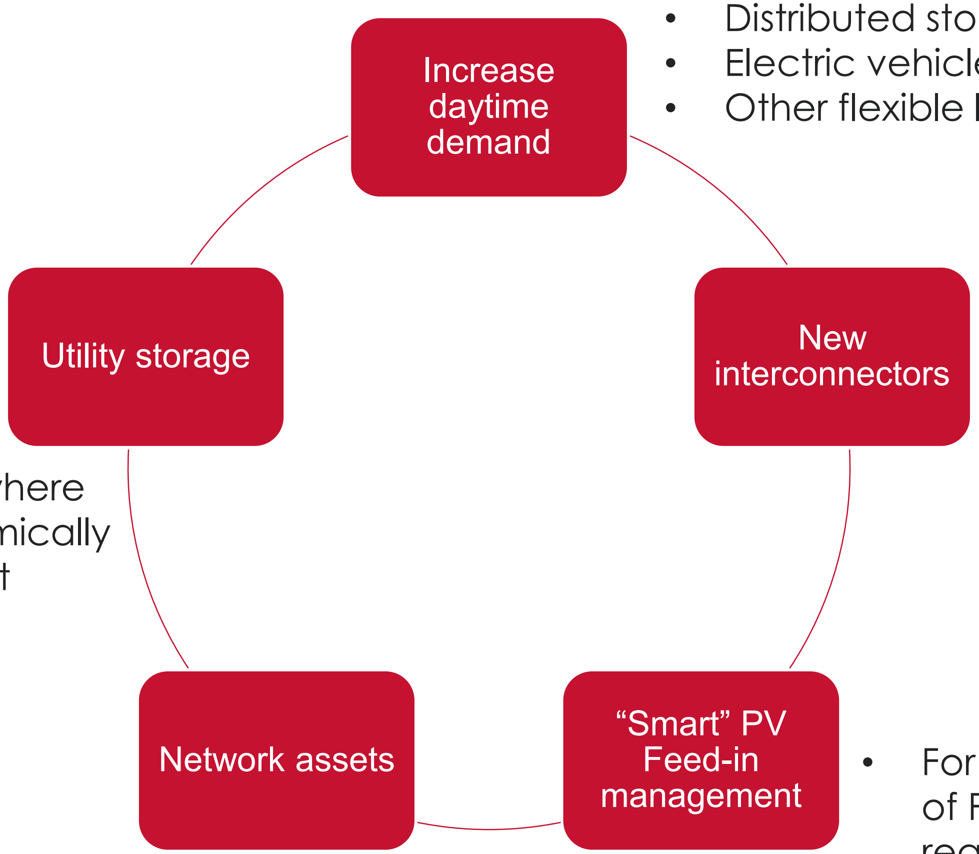
Rooftop PV has the potential for "smart" active management to provide the necessary levels of flexibility.

Operational demand in South Australia:



Options

A suite of technical options can be implemented in parallel



Increase daytime demand:

- Hot water
- Distributed storage
- Electric vehicles
- Other flexible loads

New interconnectors:

- Under consideration

"Smart" PV Feed-in management:

- For rare moderation of PV feed-in, when required for system security

Network assets:

- Voltage control
- Synchronous condensers

Utility storage:

- Utilise where economically efficient

"Smart" PV feed-in management

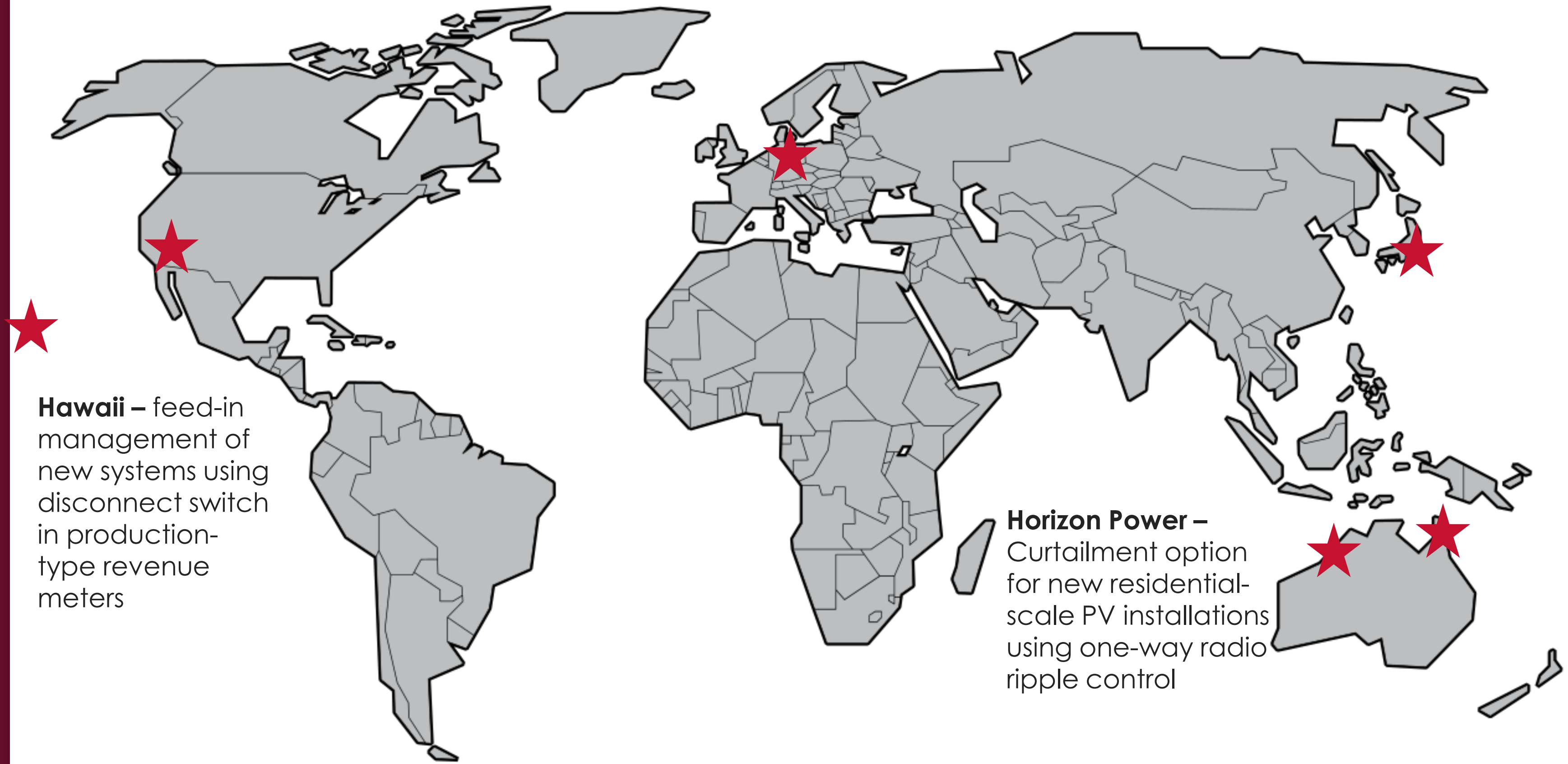
PV feed-in management has been demonstrated at scale.

Australia is one of a few countries that face the need for small-scale PV feed-in management, arising earlier than most.

Arizona – Pilot project involving 1,600 utility-owned residential PV inverters to demonstrate management of real and reactive power functionalities

Germany – Curtailment option for new residential-scale PV installations using one-way radio ripple control

Japan – multiple pilot projects testing curtailment of PV using internet communication pathways



Hawaii – feed-in management of new systems using disconnect switch in production-type revenue meters

Horizon Power – Curtailment option for new residential-scale PV installations using one-way radio ripple control

Energy QLD – Lockhart River Pilot project on a standalone microgrid investigating automated control of four PV systems using a programmable logic controller to respond to dynamic limits at the central diesel generating station

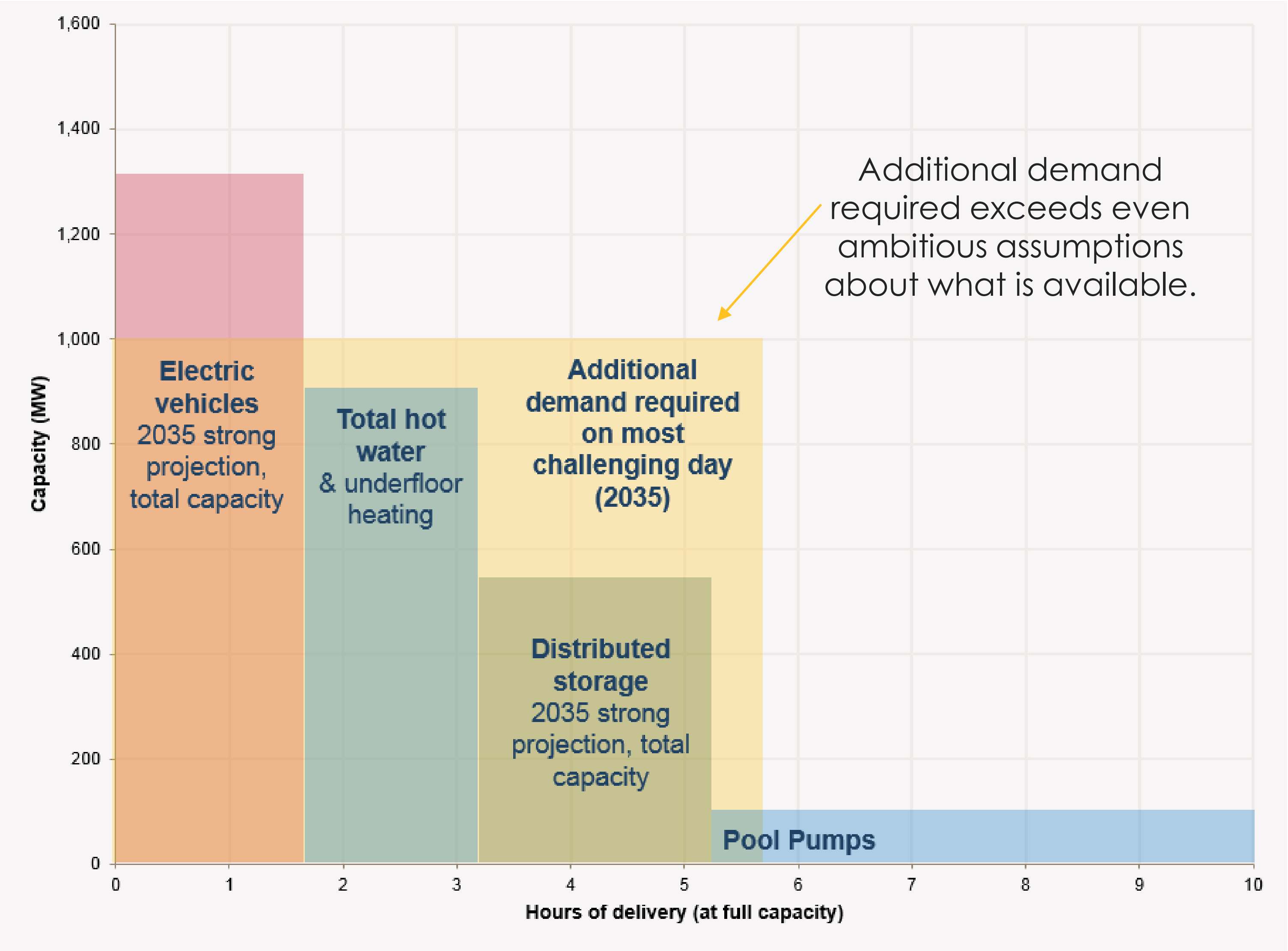
EPRI report for AEMO (2018), "International Review of Residential PV Feed-in Management".

Demand management

The amount of excess energy from rooftop PV is very large.

There is a need for "smart" capabilities, even with extensive demand response.

Maximum demand response potential in SA from a range of sectors:



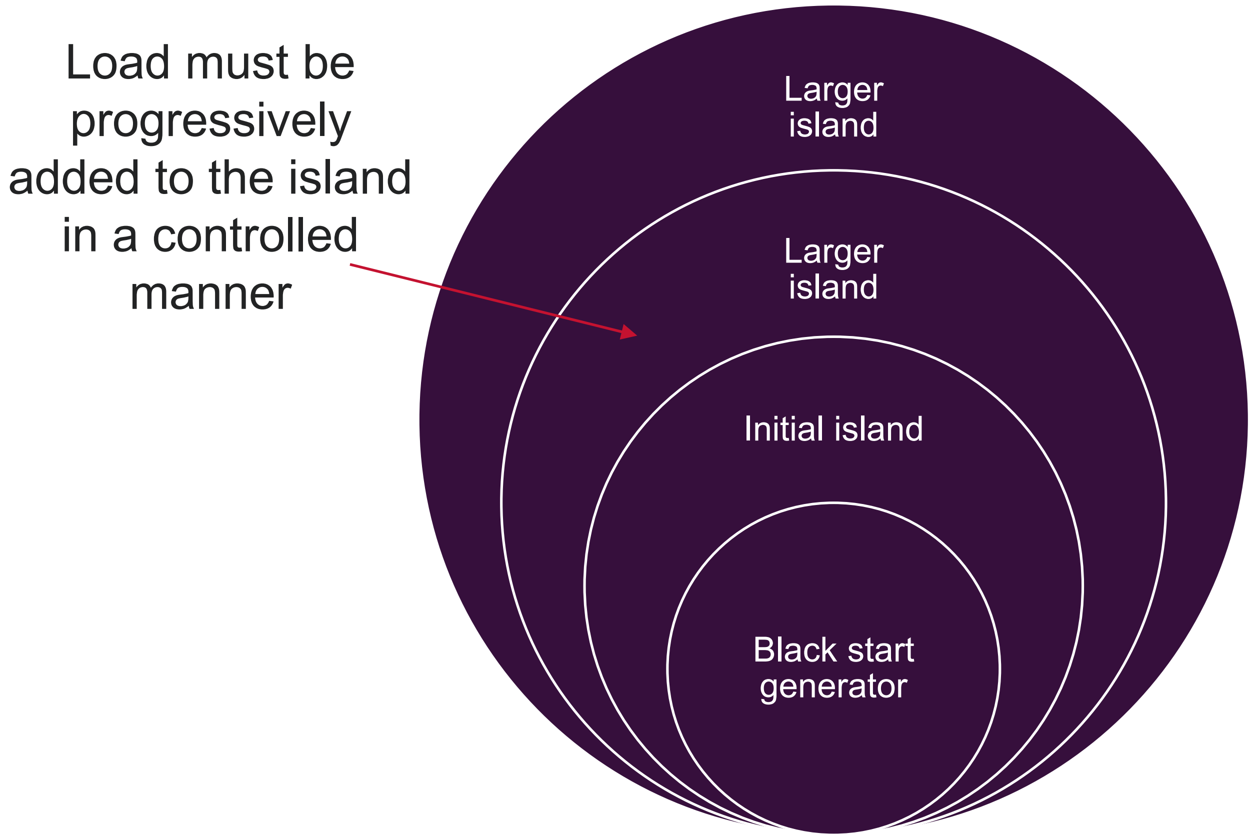
System Restoration

System black events are rare, but system operators must have resources available to restart and restore the system as safely and quickly as possible

At least two generators must be able to start up, and carry out initial energisation of a section of the system.

More generation and load is then gradually added.

The operation of uncoordinated DER may interfere with the system restoration process:



With large quantities of uncoordinated DER, it may become increasingly difficult to anticipate the quantity of load being added to the island.

Feed-in management offers a solution, if suitably designed.

VPP management

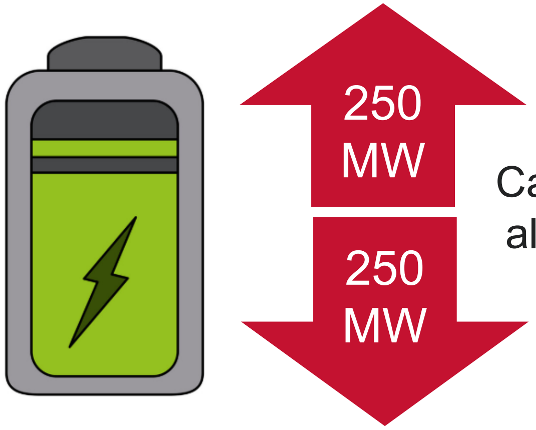
Large Virtual Power Plants (VPPs) are emerging

Operation may exceed distribution network limits

Also bring challenges at a system level

Must bring DER into system dispatch & optimisation

Tesla's proposed VPP for South Australia:



Can ramp up to 500MW almost instantaneously

Forecast errors

Escalating demand forecast errors

Regulation FCAS

Increasing enablement and use of regulation FCAS

Contingency FCAS

Large, sudden VPP movements may exceed regulation FCAS capability and trigger contingency FCAS

Security risks

Very large VPP movements may exceed capabilities of FCAS reserves, and threaten system security

Need a framework for coordination of VPP optimisation across distribution, transmission, and system dispatch

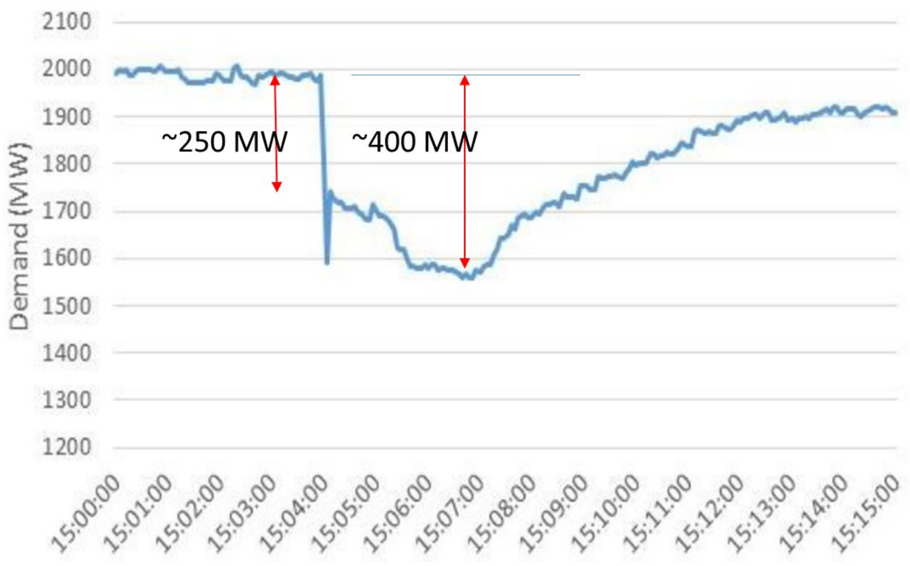
Other challenges

DER behaviour during disturbances

DER is now a significant factor in power system response to disturbances.

DER influence will grow as more is installed.

Demand in South Australia on 3rd March 2017

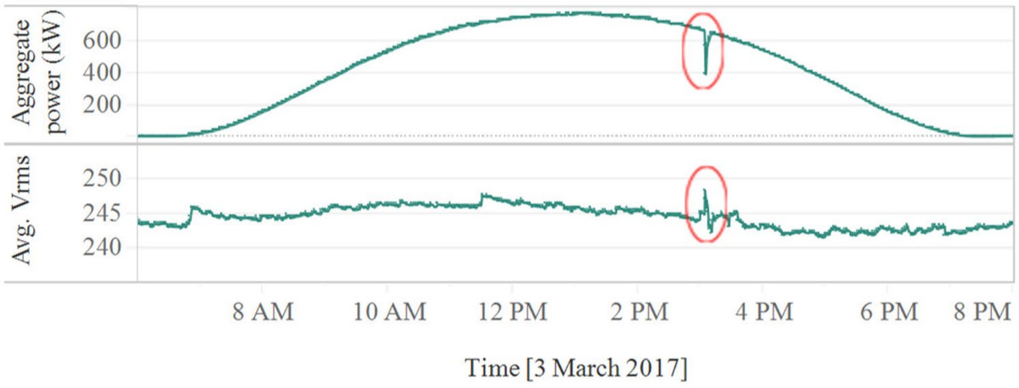


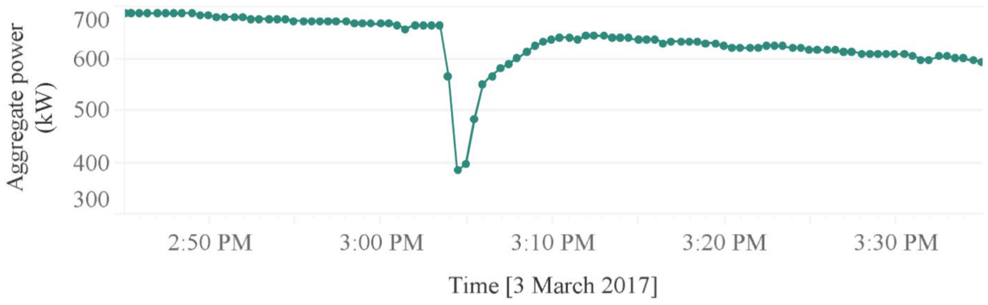
Analysis by Naomi Stringer (UNSW), data from Solar Analytics.

Faults in the Adelaide area caused ~40% of rooftop PV to cease operation

Ongoing collaborative work program to better understand DER behaviour during disturbances

PV systems behaviour:



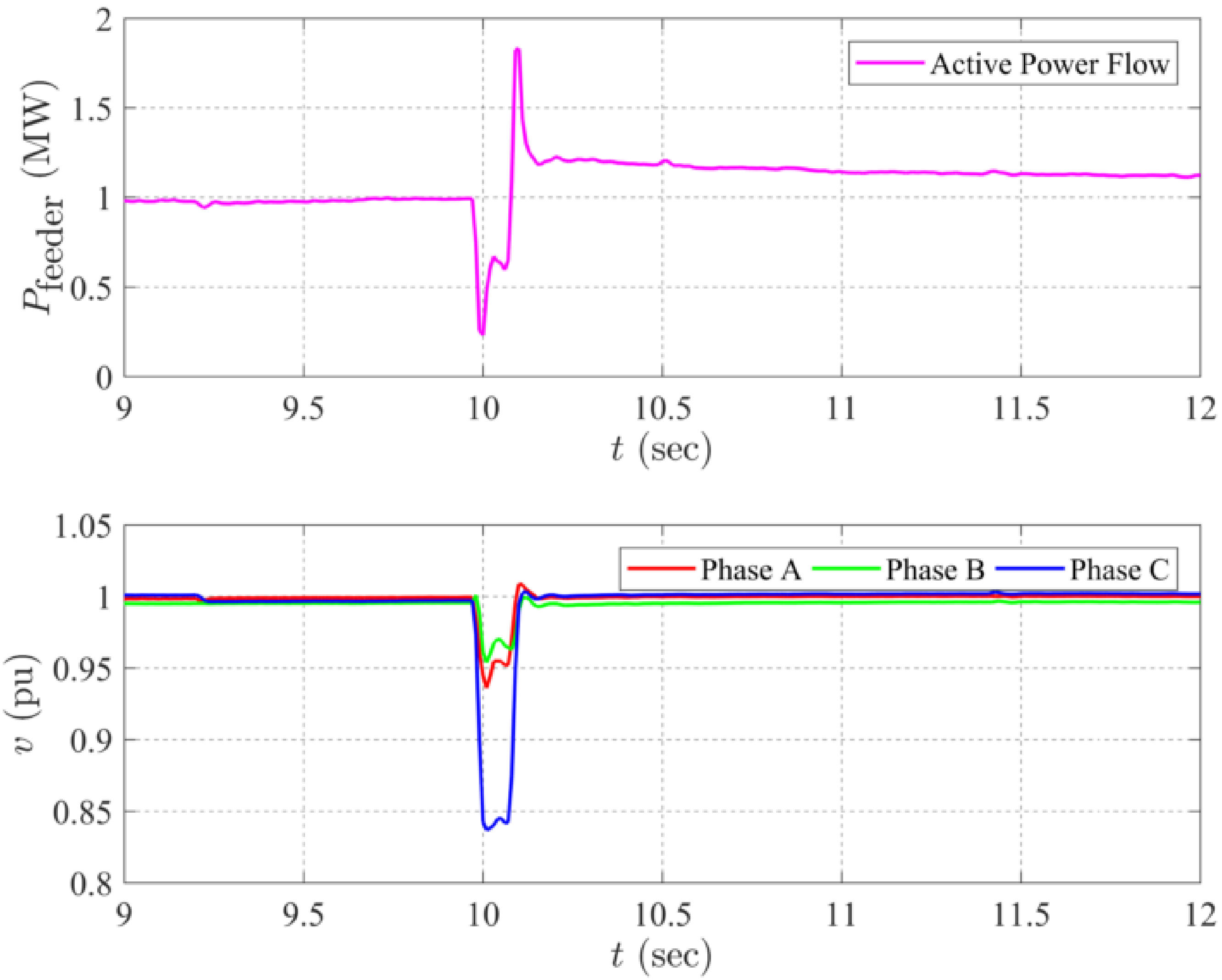


DER behaviour during disturbances

DER and load behaviour during disturbances is complex and not well understood. It is not incorporated into AEMO's dynamic models for stability assessments.

Work program underway to develop suitable models (collaboration with UNSW)

Monitoring in Energy QLD's network:



Active power **increases** after the voltage disturbance.

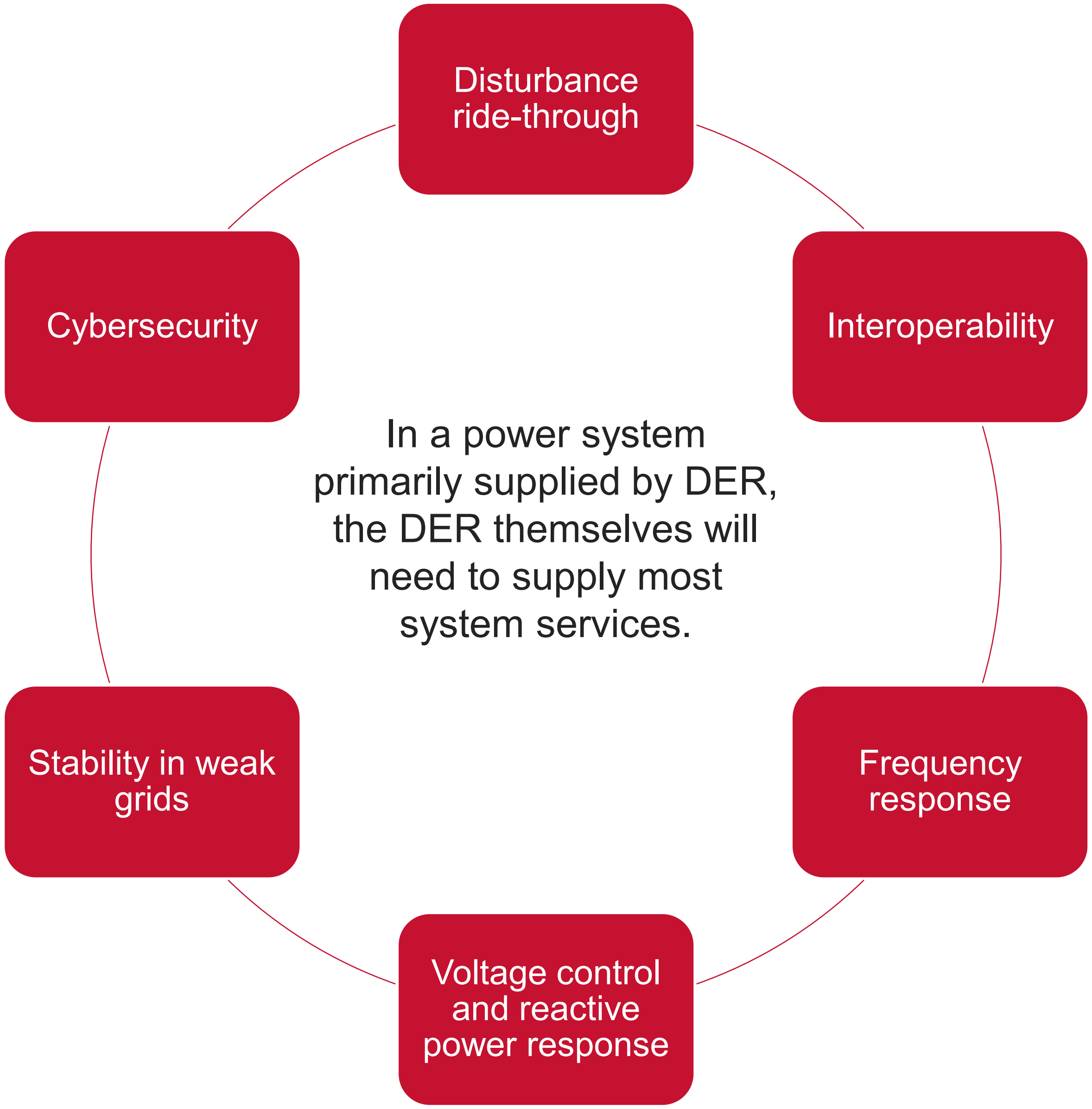
Analysis by Shabir Ahmadyar (UNSW), Data from Energy Queensland

Performance Standards

Performance standards define how generation and load must behave under different system conditions

Adequate connection standards are required to ensure that DER behaves in a way that aligns the power system needs, and system security can be affordably maintained.

Aspects of DER performance standards to review:



Emergency Frequency Control Schemes (EFCS)

- EFCS are intended as a last resort to stabilise the power system in the event of a major disturbance

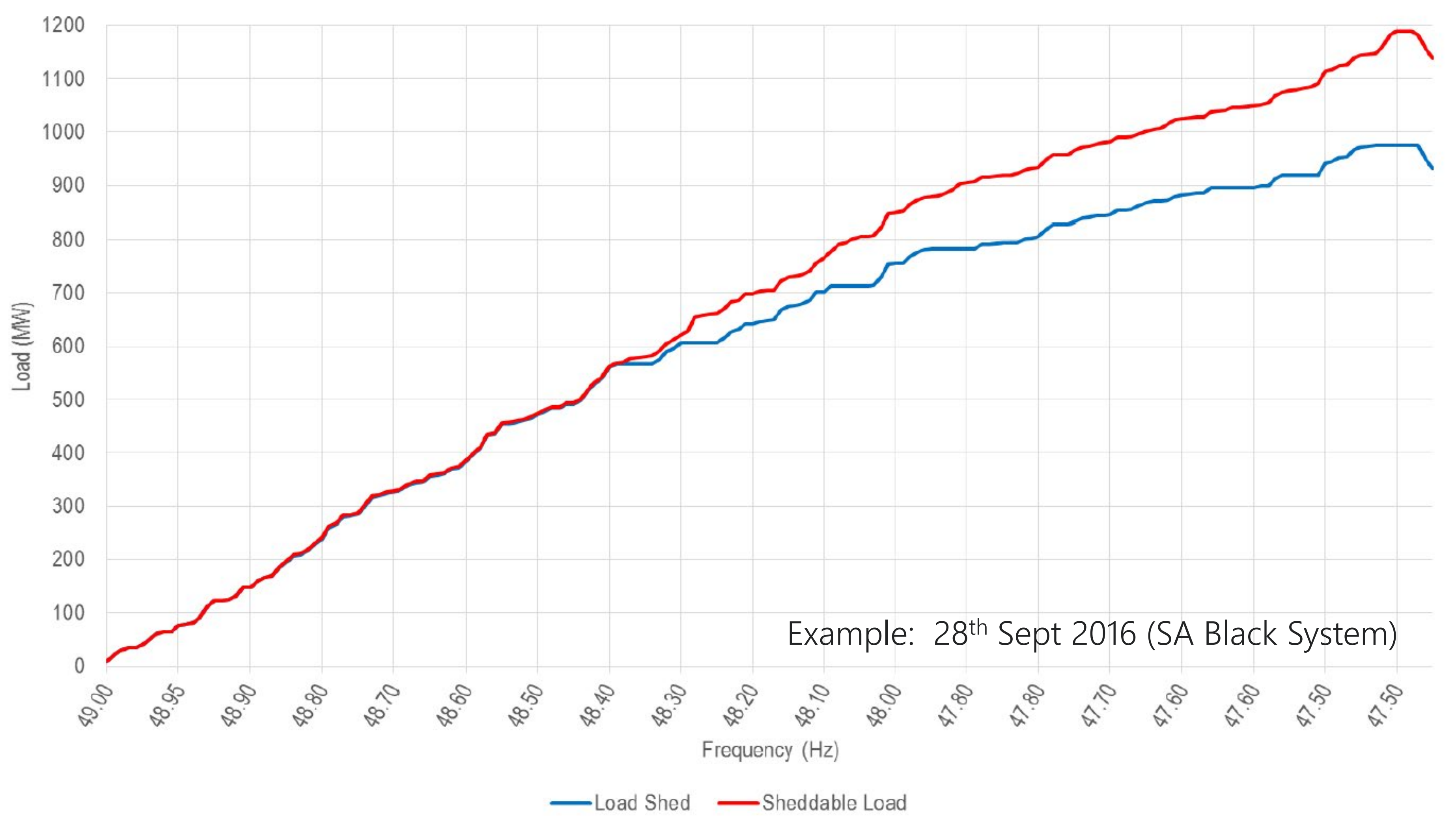
Under Frequency Load Shedding (UFLS)

- Shed load at distribution feeders using high speed relays
- Locally monitor frequency and trip in a planned sequence to produce a stable system response (decentralised response)
- Rules require >60% of regional load to be available for shedding

Over-Frequency Generation Shedding (OFGS)

- Shed generation using protection relays
- Trip settings for each unit are carefully designed and coordinated across a region to produce a stable response

UFLS load shedding profile



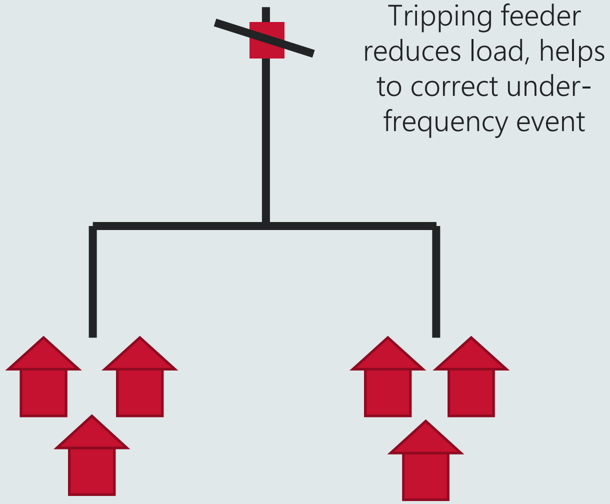
As frequency falls, load is progressively shed in an attempt to stabilise the system.

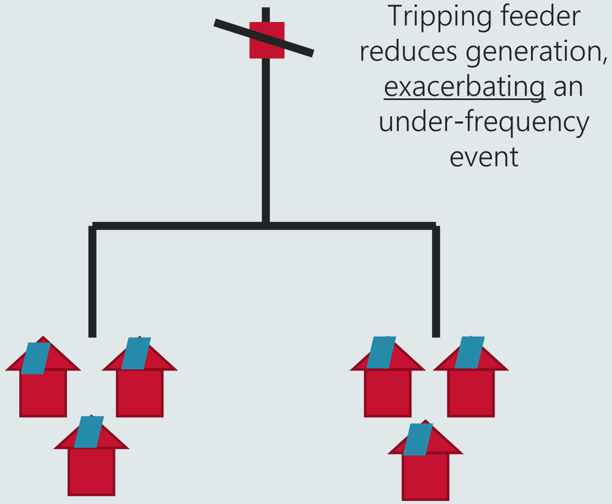
Relays at distribution feeders are pre-programmed to certain trip frequencies.

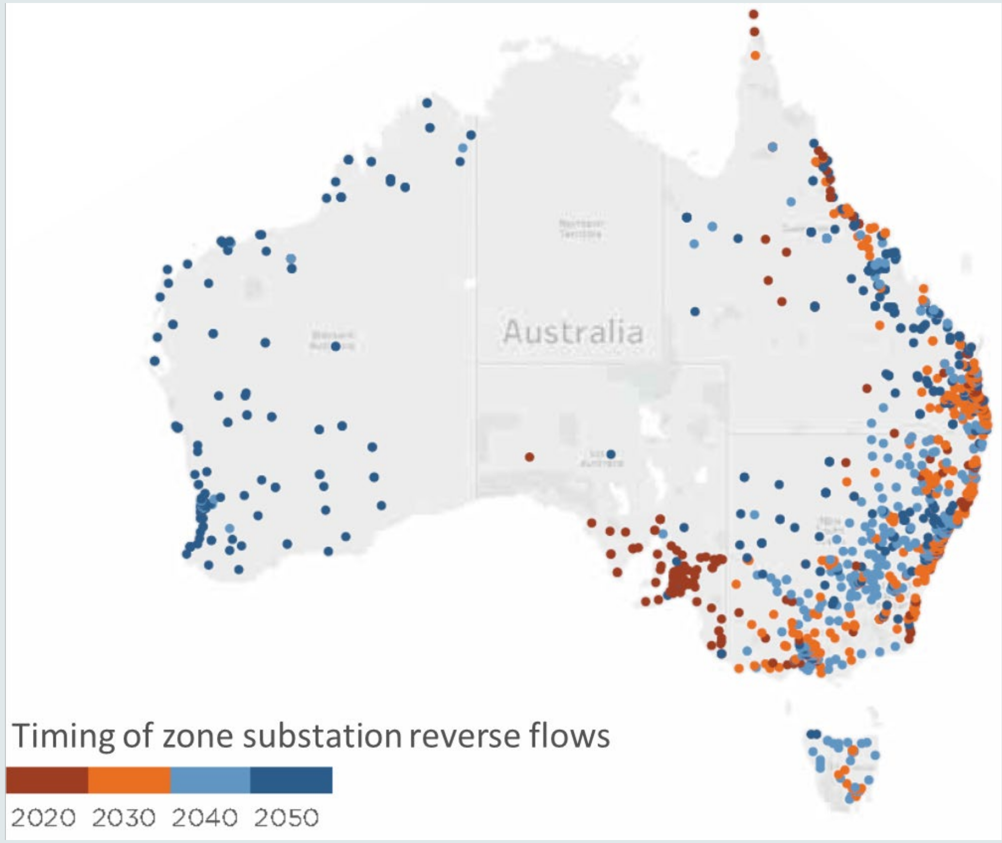
https://www.aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2017/Integrated-Final-Report-SA-Black-System-28-September-2016.pdf

EFCS Challenges

- Rooftop PV may mean that UFLS and OFGS may not operate successfully
- **UFLS** - With reverse flows, tripping a load feeder may exacerbate a disturbance, rather than helping to correct it.
- Dynamic arming (remove feeders with reverse flows) could mitigate the most significant risks







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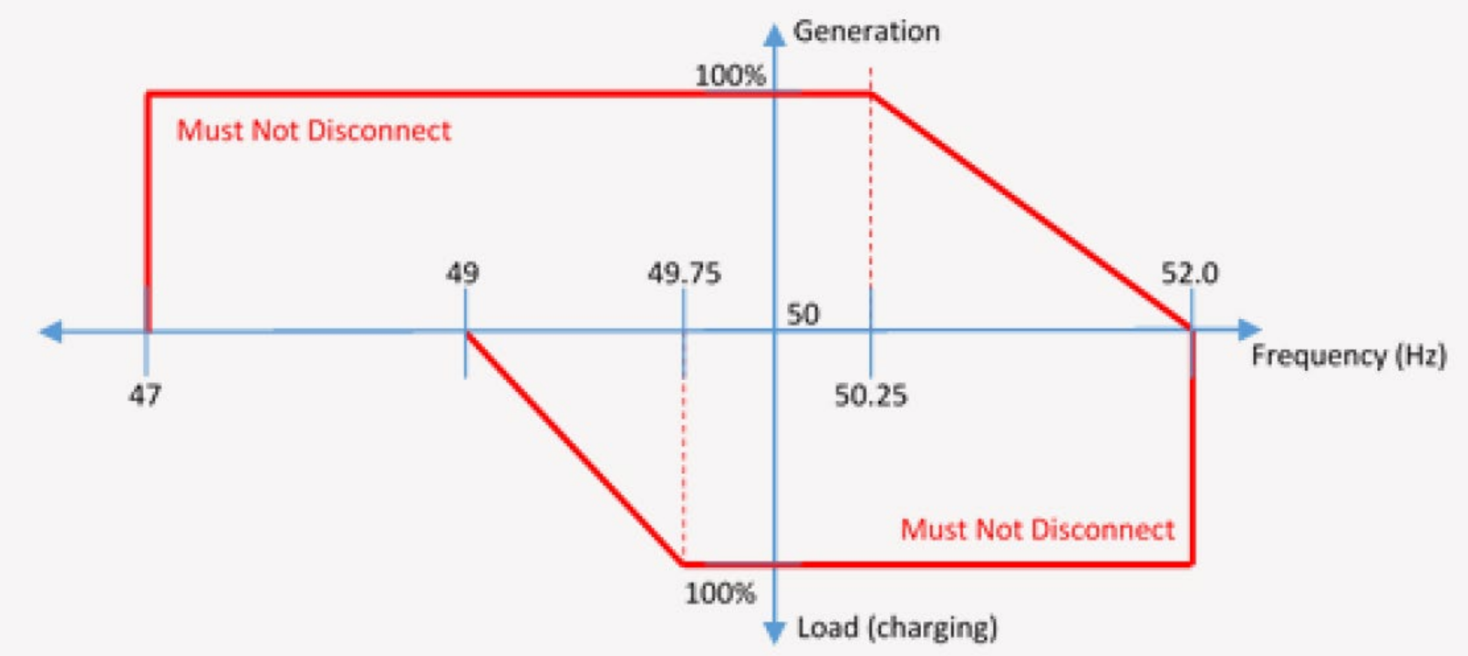
CSIRO modelling, Energy Network Transformation Roadmap, April 2017

Over-frequency generation shedding

- **OFGS** - Few centralised generators are likely to be operating at times of high DER generation (no generation is available to trip)
- New standards (AS4777.2-2015) require an over-frequency response from small PV inverters
- May be adequate
  - Implemented? (compliance?)
  - Fast?
  - Reliable?
- Further verification required
- Could it cause local voltage issues?
  - Volt-var or Volt-watt response from DER could assist?



Rooftop PV response on 25th Aug 2018

- Investigating behaviour in collaboration with UNSW (Naomi Stringer) and Solar Analytics
- Preliminary analysis suggests behaviour from many inverters is consistent with over-frequency droop response specified in AS4777.2-2015
- Outstanding questions:
  - How quickly do they respond?
  - Non-compliance from some inverters?
  - Are Solar Analytics monitored devices a representative sample?

Voltage management

Initially, voltage management challenges manifest primarily in distribution networks.

System level challenges may also emerge.

With appropriate long-term planning, issues can be managed and avoided.

Distribution level voltage management

- Wider dynamic range, changing voltage profiles

System strength

- Challenges may emerge at the distribution level with more DER connecting
- With areas of system strength changing, anticipated to emerge

Transmission level voltage management

- Potentially in future: Lack of centralised generation operating, limits access to reactive power and voltage management services

Integrating DER to maximise consumer value

DER Workstream

	Network incentives	Data visibility	System & Market framework	Technical standards & connections	Operational process	Industry-wide collaboration
Workstream objectives	Network regulation & pricing facilitate DER and better customer service offerings.	Visibility of DER for operational, forecasting, planning, and market (incl settlement) functions. A consistent access regime for all market participants within the confines of customer consent and privacy.	Integrate DER into energy, ancillary and reserve markets. Market arrangements recognise non-retailer models, including third-party/aggregator concepts. Evolve market arrangement to a distributed market model.	Where appropriate, a nationally consistent approach to DER connections and develop DER technical standards.	To better understand operational challenges and DER capabilities to inform operational processes and tools.	Industry working together to deliver outcomes for consumers

Enablers

- Pilot programs
- Cyber security
- Digital & Technology Strategies

- DER represents a significant transition
- A coordinated and collaborative work program is required
- By identifying challenges early, we can implement the measures required to affordably maintain security and reliability for customers throughout this transition
- Enable maximum customer choice and value

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Thank you