Distributed PV
An overview of the RIS Technical Appendix A
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Renewable Integration Study 101
Renewable Integration Study Technical Overview
Distributed PV
Managing Frequency
Variability and Uncertainty

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Today’s Webinar

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

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

Over 2.2 million DPV systems installed across the NEM
Residential < 10kW
Commercial 10 kW to 100 kW
Industrial 100kW to 30 MW
Electricity supply chain

Generators → Transmission Network → Distribution Networks → Meter → Consumers

Bulk System Operation (AEMO)
DPV from a system operator’s perspective

Asynchronous
(see Appendix B)

Variable
(see Appendix C)

Decentralised

Large-scale Generation

Visible

Performance aligned to power system needs

Controllable

DPV

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

DPV erodes operational demand during the daytime.
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?

For more information refer to Section A2
Core areas of analysis
Distribution network challenges
Distribution networks

- **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)**

For more information refer to Section A3
Challenges

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.

For more information refer to Section A3.2 and A3.3.
Visibility is a key enabler for optimised, efficient DPV integration.

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

For more information refer to Section A3.4 and A3.5.
Bulk power system challenges
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?

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For more information refer to Section A4
NEM: Bulk system operation out to 2025

Increasing demand

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

Large amount of instantaneous DPV generation

High-demand periods (e.g. summer with lots of air-con) DPV meets part of this demand

Low-demand periods with high of DPV (e.g. sunny, spring day)

For more information refer to Section A2.3
Regions: Bulk system operation out to 2025

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

![Graph showing distributed PV penetration and underlying demand](image)
Case study: Effectiveness of under-frequency load shedding (UFLS) schemes

If a sudden significant loss of generation were to occur during high DPV generation, low load conditions:

- **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

For more information refer to Section A4.2.2
**Zone B:**

Material risk of mass DPV disconnection

Contingency risks associated with mass DPV disconnection
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.

For more information refer to Section A4.1.
Zone C: Insufficient load for system security

Minimum synchronous generation requirements

Power system dispatchability

Operational levers during extreme abnormal conditions

Reference Thresholds
- Minimum nighttime operational demand (2019)
- Contingency size: DPV loss less load loss (% capacity of largest generating unit in region)
- Minimum synchronous unit requirement

Operating Zone
- Zone A
- Zone B
- Zone C

Dispatch
- 2019 (Actuals)
- 2025 (ISP Central)
- 2025 (ISP Step Change)
Case study: need for last resort DPV curtailment

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

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

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
Bulk system operation out to 2025

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

- DNSPs are pursuing network and behind-the-meter measures behind-the-meter measures
- Increasing technical challenges to distribution and bulk power system
- DPV is largely passive

Visibility is critical to improving hosting capacity

A suite of measures is required to optimise bulk system operation

Last resort, backstop mechanisms will still be needed

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

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.

For more information refer to Section A5
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.
Watch the rest of the series
