Data-driven assessment of DPV inverter behaviour under enhanced voltage management

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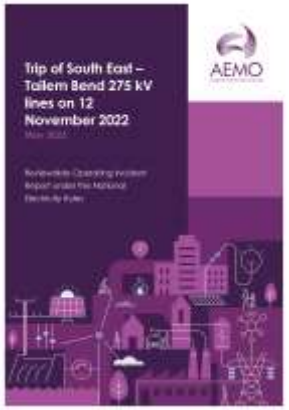
Phoebe Dennis, Naomi Stringer, Anna Bruce, Iain Macgill
Collaboration on Energy and Environmental Markets (CEEM)
School of PV and Renewable Energy Engineering
UNSW Sydney Australia

November 2022 event



Power system incident

- At 4:39pm AEST on 12 November 2022, storms caused a transmission tower in SA to fail and resulted in the state islanding from the rest of the NEM.

Island operation

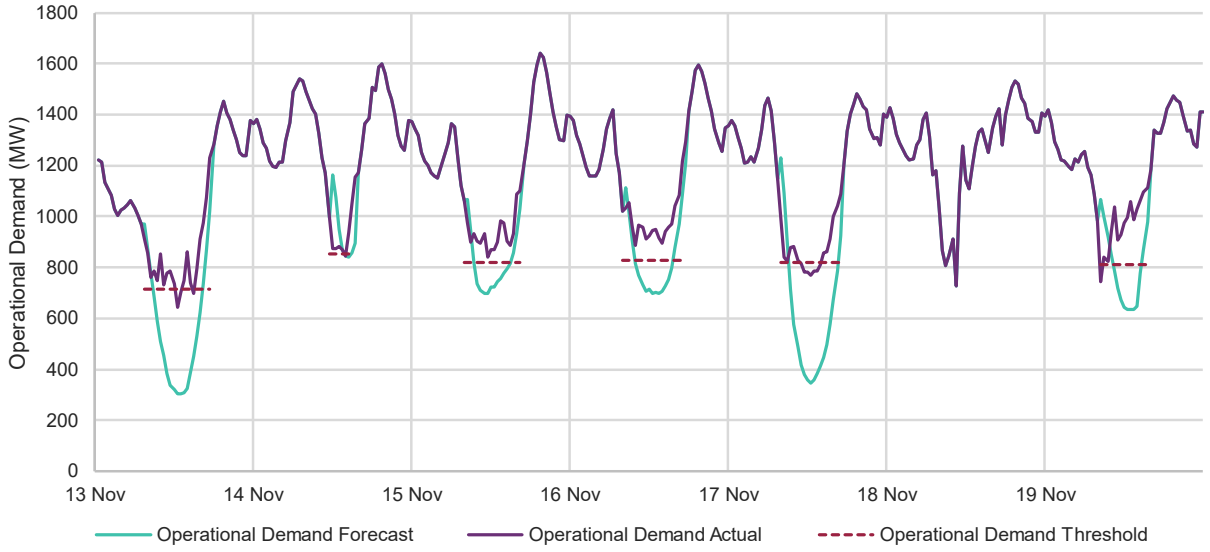
- For the following seven days, the electricity grid in SA operated as an island. Forecast high generation from DPV raised concerns of minimum operational demand being exceeded and AEMO used DPV curtailment to maintain power system security.

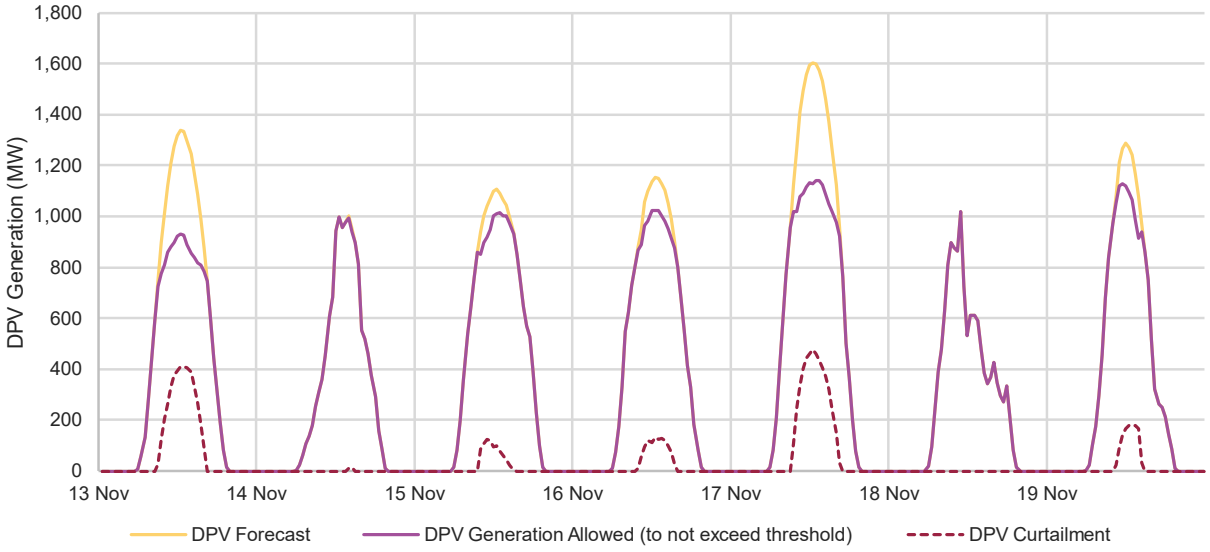
Methods of curtailment

- The distribution network service provider in SA, SA Power Networks (SAPN), used four mechanisms to curtail solar PV:
  - SCADA controlled generation,
  - Smarter Homes regulations,
  - Flexible Exports, and
  - Enhanced Voltage Management (EVM)

See: https://aemo.com.au/-/media/files/electricity/nem/market_notices_and_events/power_system_incident_reports/2022/trip-of-south-east-tailem-bend-275-kv-lines-november-2022.pdf?la=en

Island operation





Enhanced Voltage Management

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What is it?

- Increase distribution voltages to reduce DPV generation

Outcomes

- Estimated that at least 60% of DPV curtailment in this event was delivered by EVM
- Would still have been required even with higher compliance of Relevant Agents, but would have enacted less extensively and for shorter duration.
- Does not rely on availability of internet or telecommunications, and delivered a consistent and reliable response on 13 and 14 November during telecommunications loss

Expected response of PV inverters

- Depends on the standard version applied on the inverter and the voltage reached
- Some combination of
  - Anti-islanding trip
  - Sustained over-voltage trip
  - Power quality (PQ) responses:
    - Volt-Watt response
    - Volt-VAr response

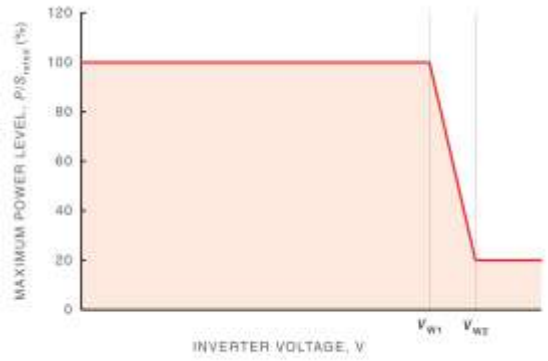

Figure 3.1 — Example curve for the volt-watt response mode

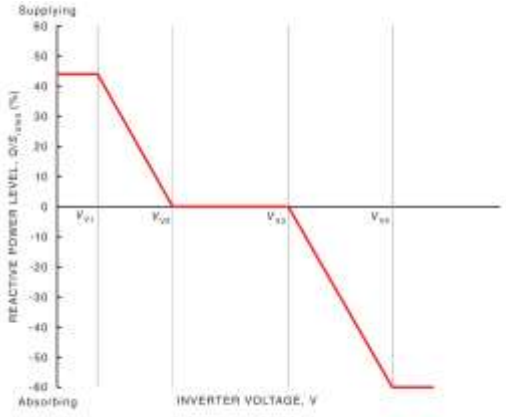

Figure 3.2 — Example curve for the volt-var control mode

Method

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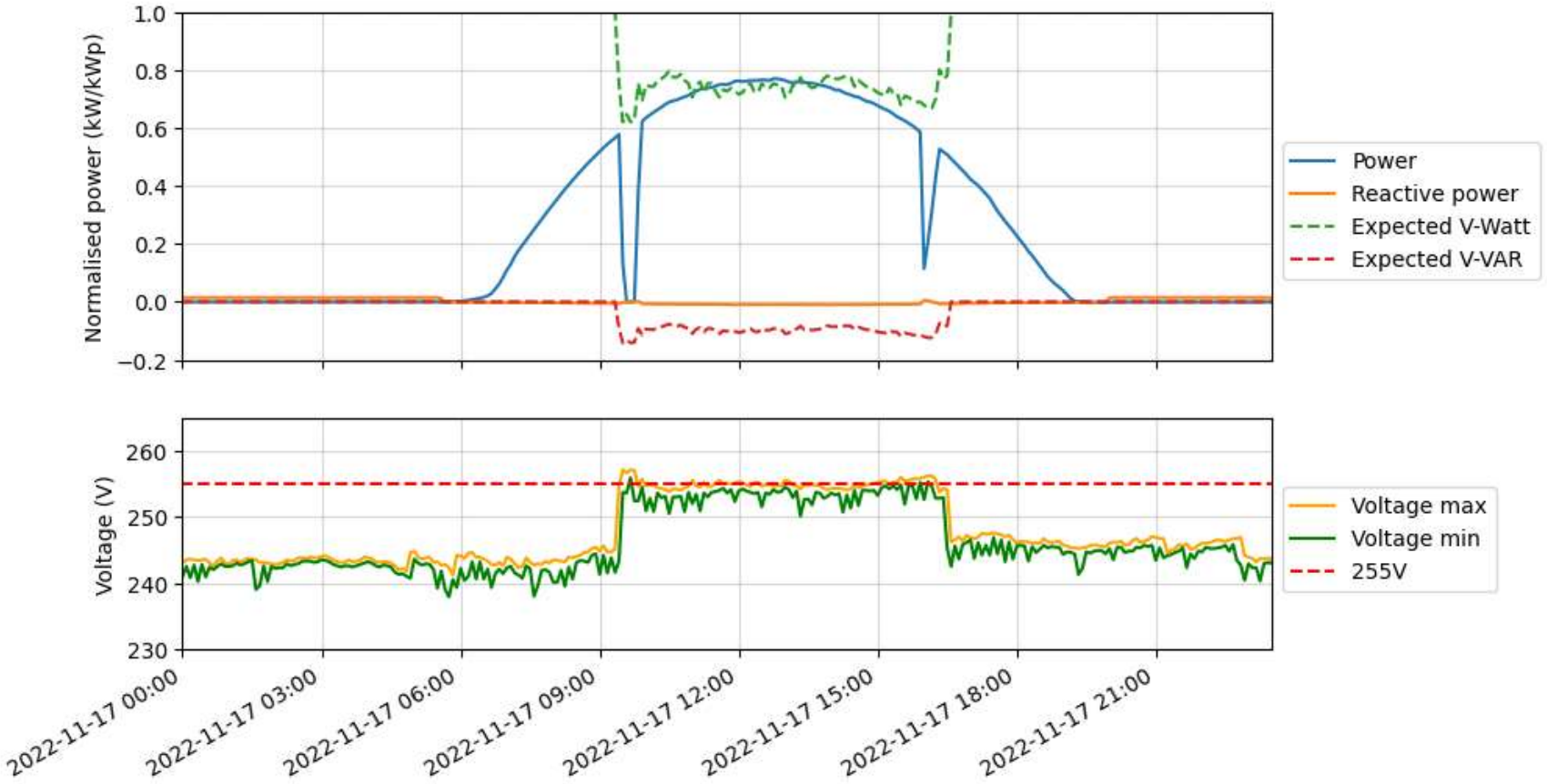
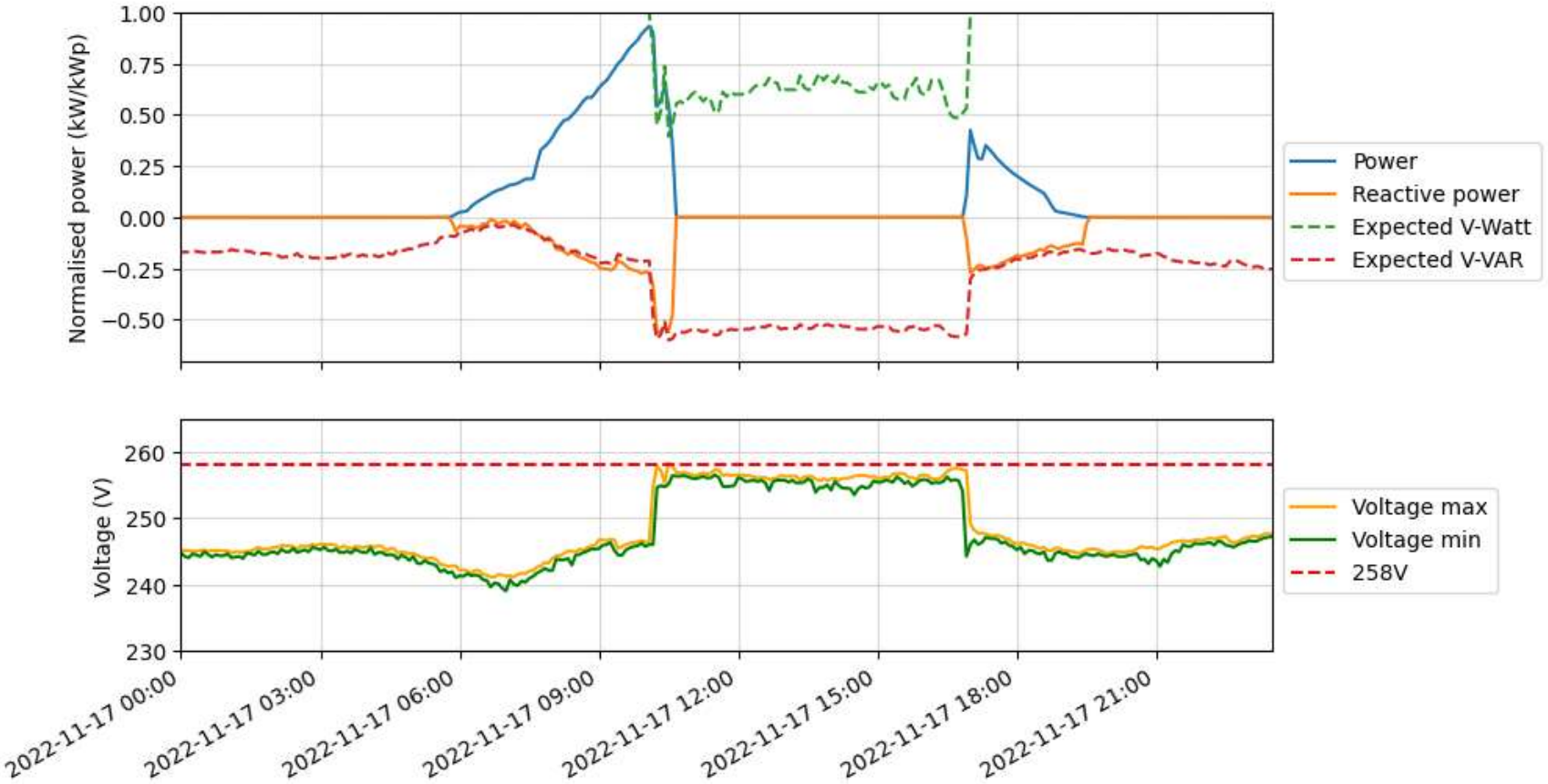
- The analysis focussed on a single day, the 17th of November, because it was a clear sky day.
- Data was collected from around 2800 sites at a 5-minute resolution from Solar Analytics.

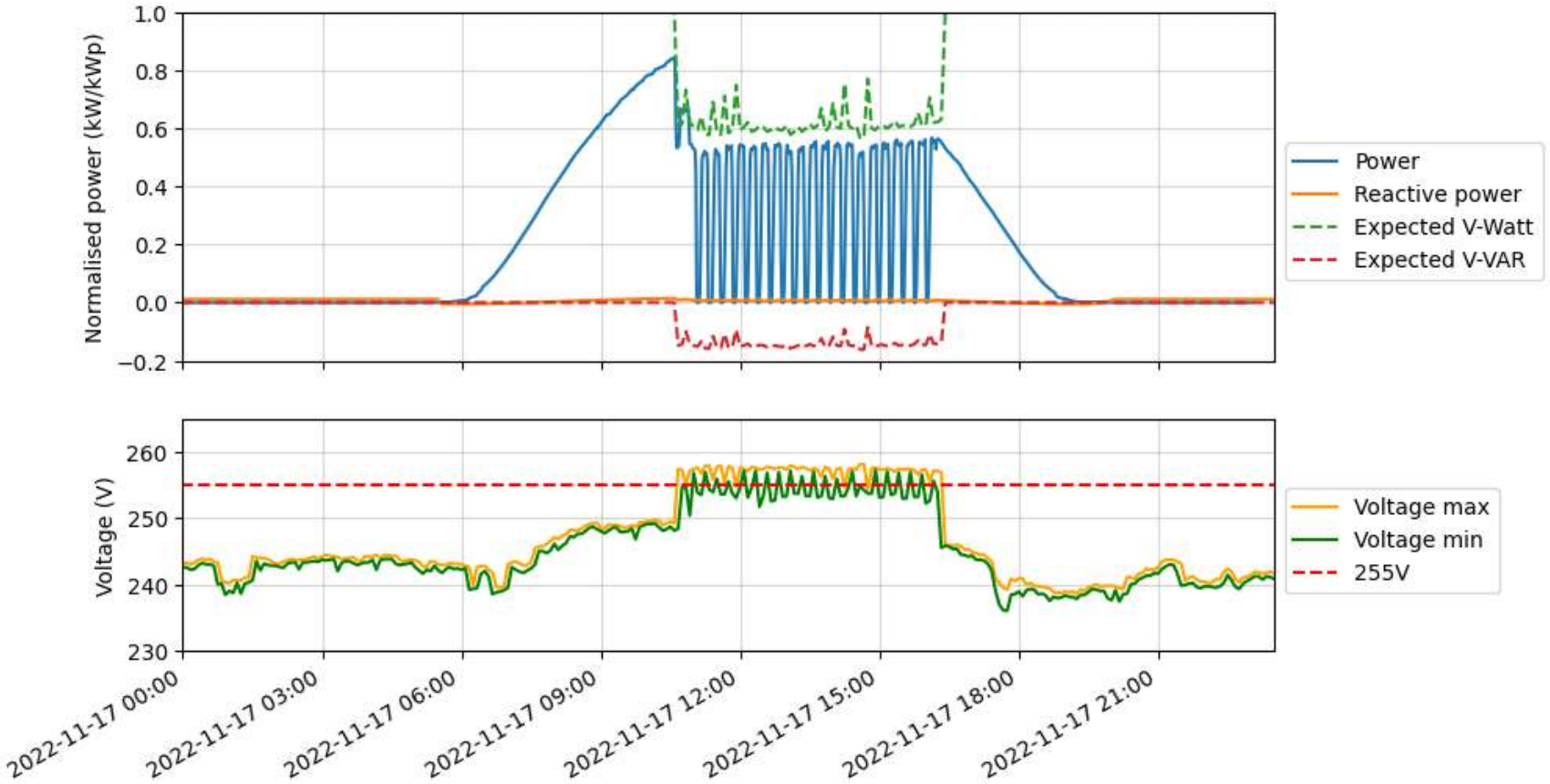
Example response 1 – short disconnect



Example response 2 – long disconnect



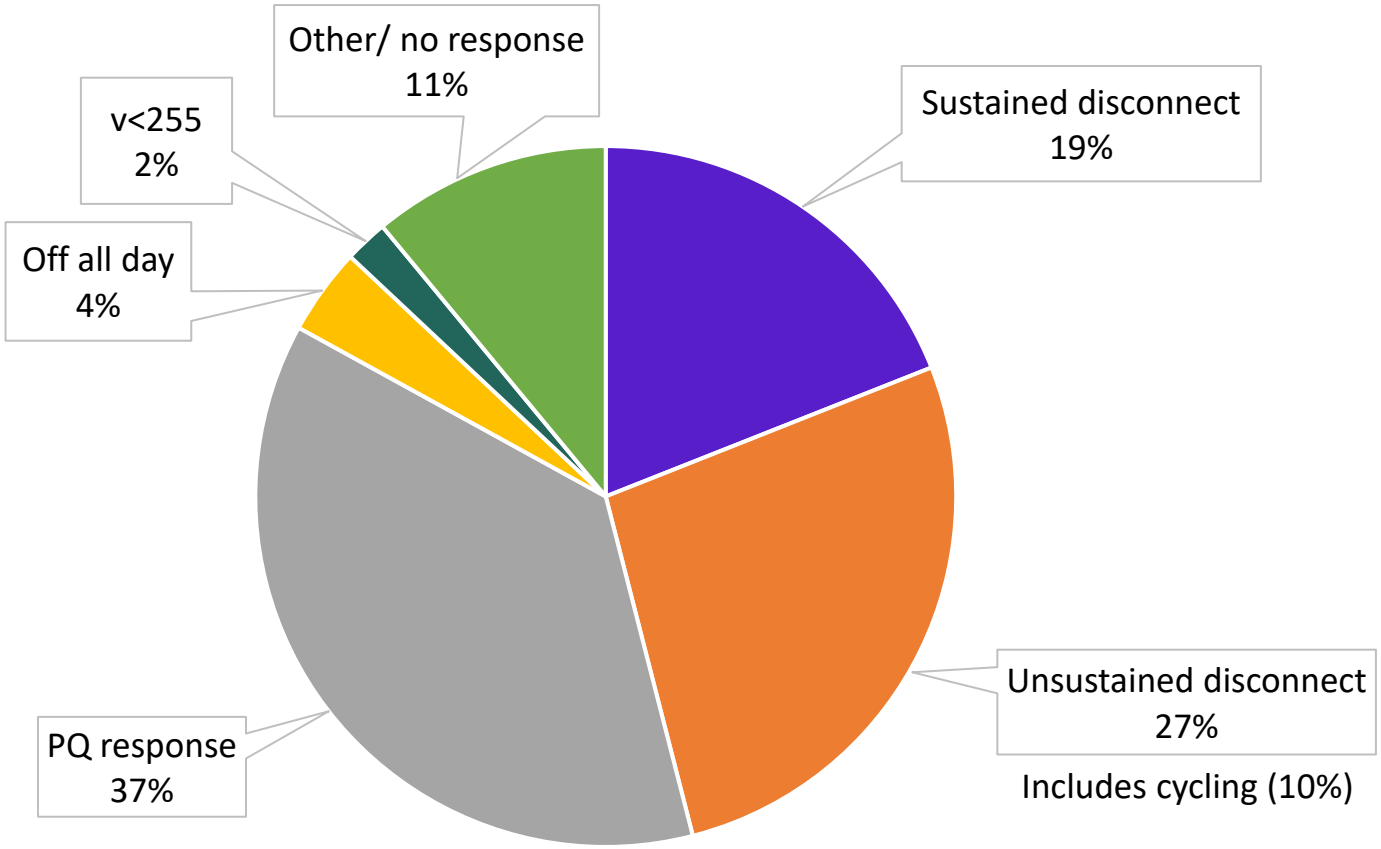
Example response 3 – cycling



Response types

Category		Criteria
Sustained disconnect		Power dropped to less than 5% of rated capacity for at least 4 hours consecutively.
Unsustained disconnect		Power dropped to less than 5% of rated capacity for at least 1 timestep and less than 4 hours, or non-consecutively.
PQ response	V-VAr	Reactive power decreased to more than 10% of rated power.
	V-Watt	Power stayed below 95% of the V-Watt curve.
Off all day		Power remained at less than 5% of rated power between 8:30am and 5:30pm.
Low voltage		Site voltage was not measured to exceed the 255V threshold.
Other/ no response		The site did not fall into any of the other categories.

Categorised responses



Outcomes

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- EVM was an effective method for reducing the output of DPV under emergency minimum demand conditions.
- It has some limitations such as causing cycling in DPV output.
- The impacts of elevated voltages on appliances are unclear and EVM is only anticipated to be used as a last resort (similarly to Under Frequency Load Shedding).
- EVM is also expected to become less effective as more DPV systems are installed under AS4777.2:2020 and have power quality responses enabled to help lower local voltages before they reach the tripping setpoint.

Future work

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- Data from this event may be used to assess compliance of DPV with technical settings
- Work is underway to investigate the implications of elevated voltages for virtual power plant operations especially FCAS delivery

Q&A

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ASIA-PACIFIC SOLAR RESEARCH CONFERENCE

AUSTRALIAN PV INSTITUTE

UNSW SYDNEY