



Large Power Electronic Loads – Challenges and Insights

Opportunity and impact

ISON has been collaborating to address challenges and opportunities related to the increasing connection of large Power Electronic Loads (PELs) into bulk power systems. PELs are loads utilising software controls to manage load behaviour and include data centres, cryptocurrency mining facilities and hydrogen electrolysers. By sharing information on connecting and operating PELs and reviewing PEL-related system events, System Operators (SOs) can apply the lessons learned and best practices developed by peers.

System Operators engaged

The following SOs were involved:

- AEMO – Australia
- CAISO – United States (California)
- EirGrid – Republic of Ireland
- Energinet – Denmark
- ERCOT – United States (Texas)
- NESO – Great Britain

This document is intended for general and high-level information only, based on knowledge available to the SOs as at the date of publication. It does not constitute legal, business, engineering or technical advice, and should not be relied on as a substitute for obtaining detailed advice about individual electricity systems and their regulation. AEMO, CAISO, EirGrid, Energinet, ERCOT and NESO have made reasonable efforts to ensure the quality of information but cannot guarantee its accuracy or completeness.

Key insights

PEL load reduction events

- PEL loss events are predominantly caused by voltage disturbances from system faults resulting in PELs switching to backup power supplies. There is potential for such disturbances to result in disconnection or active power reduction from facilities across a broad area of the system. The cumulative impact of this may increase load contingency sizes, potentially exceeding the maximum contingency size that operators plan and operate their systems to cater for.
- EirGrid has experienced multiple events involving large aggregate demand reduction from data centres in recent years. All caused significant supply-demand imbalances and sharp increases in rate of change of frequency (RoCoF) and frequency. The largest demand reduction observed to date was caused by a system fault in Dublin in May 2025, with aggregated demand reduction of approximately 400 megawatts (MW), approximately half of all online large data centre load.



- A 1,500 MW load loss event in North Virginia occurred in 2024, leading to a frequency rise of 0.047 hertz (Hz) and a voltage rise of 0.07 per unit (pu) from nominal levels. Protection schemes in data centres triggered disconnection after three voltage disturbances were recorded within one minute.
- Between 2023 and 2024, ERCOT experienced 19 events where more than 100 MW of PELs disconnected from the power system due to voltage disturbances, with the greatest reduction being 432 MW. ERCOT has identified that the Texan grid can withstand a load loss of up to 2,600 MW in worst-case foot-room conditions, a limit quickly being approached as the penetration of PELs in Texas increases.

Other PEL-related challenges

- Modelling of fault ride-through performance of PELs will remain a challenge for SOs until the modelling capability for PELs is further developed and widely available.
- The ability for PELs to ramp from near-zero demand to, in some cases, over 90% capacity within seconds means their operating patterns and demand profiles can present operational challenges.
- While the connection of additional large load may help mitigate some minimum system load (MSL) challenges, increasing contingency sizes from PEL loss events could raise MSL thresholds.
- Inverter-based loads may also face converter-driven stability challenges, as experienced by some inverter-based generation.

Opportunities associated with PEL connection

- In Australia and potentially elsewhere, PELs have the potential to assist in mitigating challenges associated with MSL driven by periods of peak solar generation.
- Uninterruptable power supply (UPS) systems utilised by PELs have potential to provide system services, such as fast frequency response.

PEL standards in grid codes

- Energinet has implemented retroactive fault ride-through standards for large loads above 200 MW.
- ERCOT has proposed non-retroactive fault ride-through standards for large loads (above 75 MW).
- EirGrid is developing proposals for fault ride-through standards to be applied to all large demand facilities.
- NESO is undertaking a grid code modification process to develop fault ride-through requirements. In the interim, fault ride-through technical requirements are included in bilateral agreements with load users to mitigate the risk of load loss events.

PEL-focused initiatives

- PEL initiatives have been launched by NERC (Large Loads Task Force), EPRI (DCFflex), ESIG (Large Loads Task Force), and CIGRE (Large Load Task Force).



- ERCOT has launched several internal initiatives, including load forecasting for PELs, dynamic model development, investigating prohibition of oscillating and pulsating load characteristics, establishing a fault ride-through evaluation process, developing stability studies for PELs, and modifying its interconnection process.
- EirGrid is developing a stakeholder information paper which will provide background to the fault ride-through issue, examples of actual system events, power system studies of current and future scenarios, and mitigations/solutions proposed for the currently contracted level of data centre demand.
- AEMO is presently working with the Australian Energy Market Commission (AEMC) on proposed amendments to the technical requirements for large load connections in Australia's National Electricity Market (NEM). To inform these requirements and other potential regulatory development, AEMO is engaging with original equipment manufacturers (OEMs) to better understand the capability and limitations of PEL technologies, and undertaking system studies to assess the impact of PELs on system security and network operability. AEMO is also investigating the development of independent long-term data centre forecasts to inform network planning activities.
- NESO is engaging with large load users to understand the dynamic performance of the load and potential solutions for meeting the fault ride through requirements.

Recommendations

It is recommended that SOs:

- **Identify collaboration opportunities to address current PEL-related challenges, particularly in PEL modelling.**
- **Develop and implement fit-for-purpose fault ride-through standards to protect power systems against load loss events caused by voltage disturbances.**

Contact

For any specific feedback on this Knowledge Sharing Brief, please contact contact@isonetwork.org.