Operability Challenges with Large Data Centre Load

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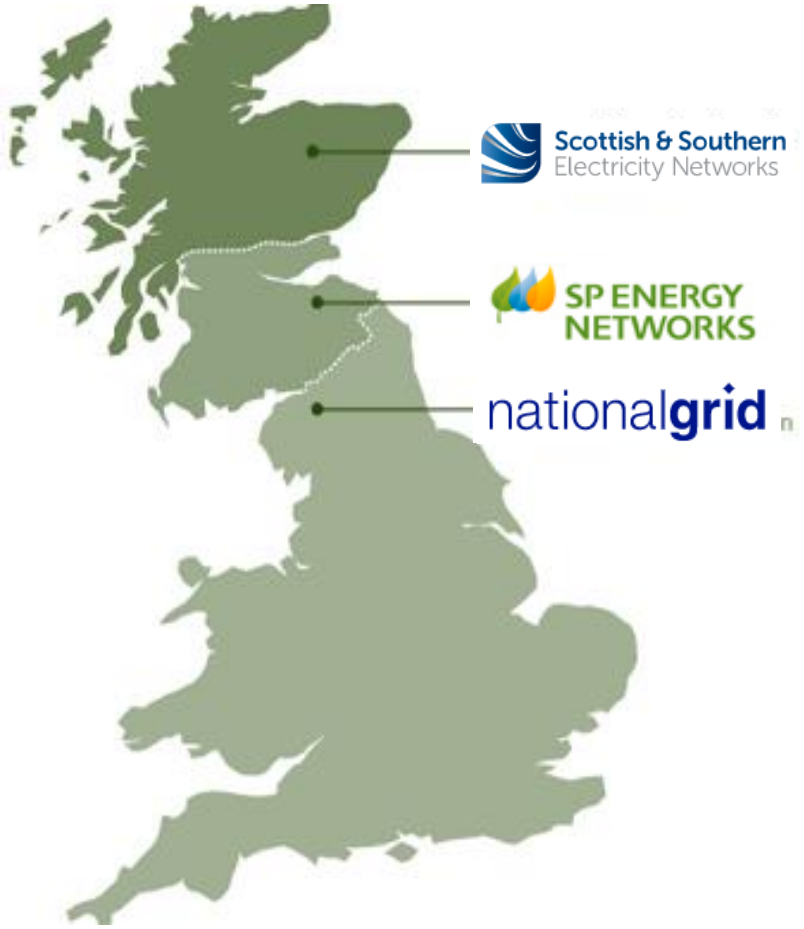
National Energy System Operator

NESO's role

- Operates and balances the system
- Provides electricity network recommendations
- Operational planning
- Connection agreements
- Widens access and promotes competition

NESO (National Energy System Operator) from Oct 2024

The **transmission operators** (TOs) own, build and maintain Britain's transmission infrastructure.



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How GB system evolves

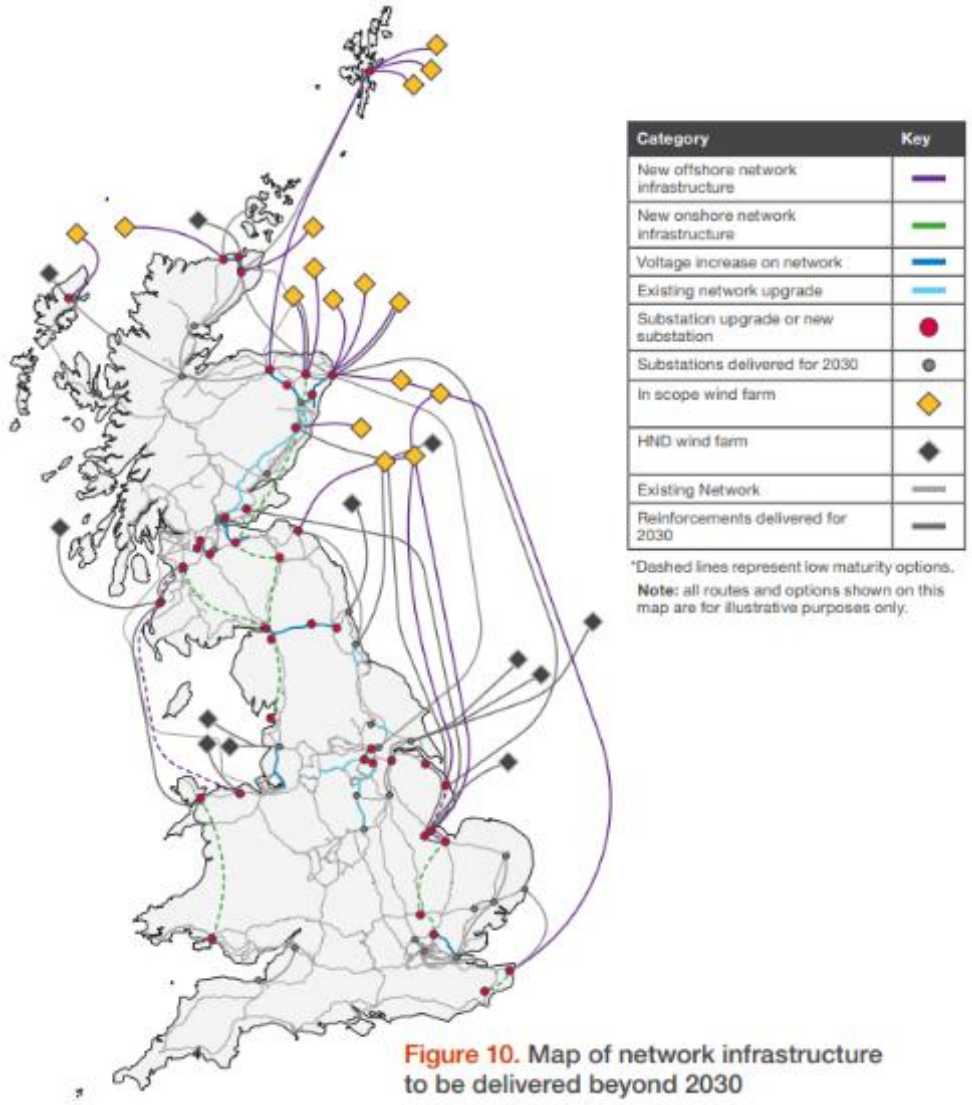
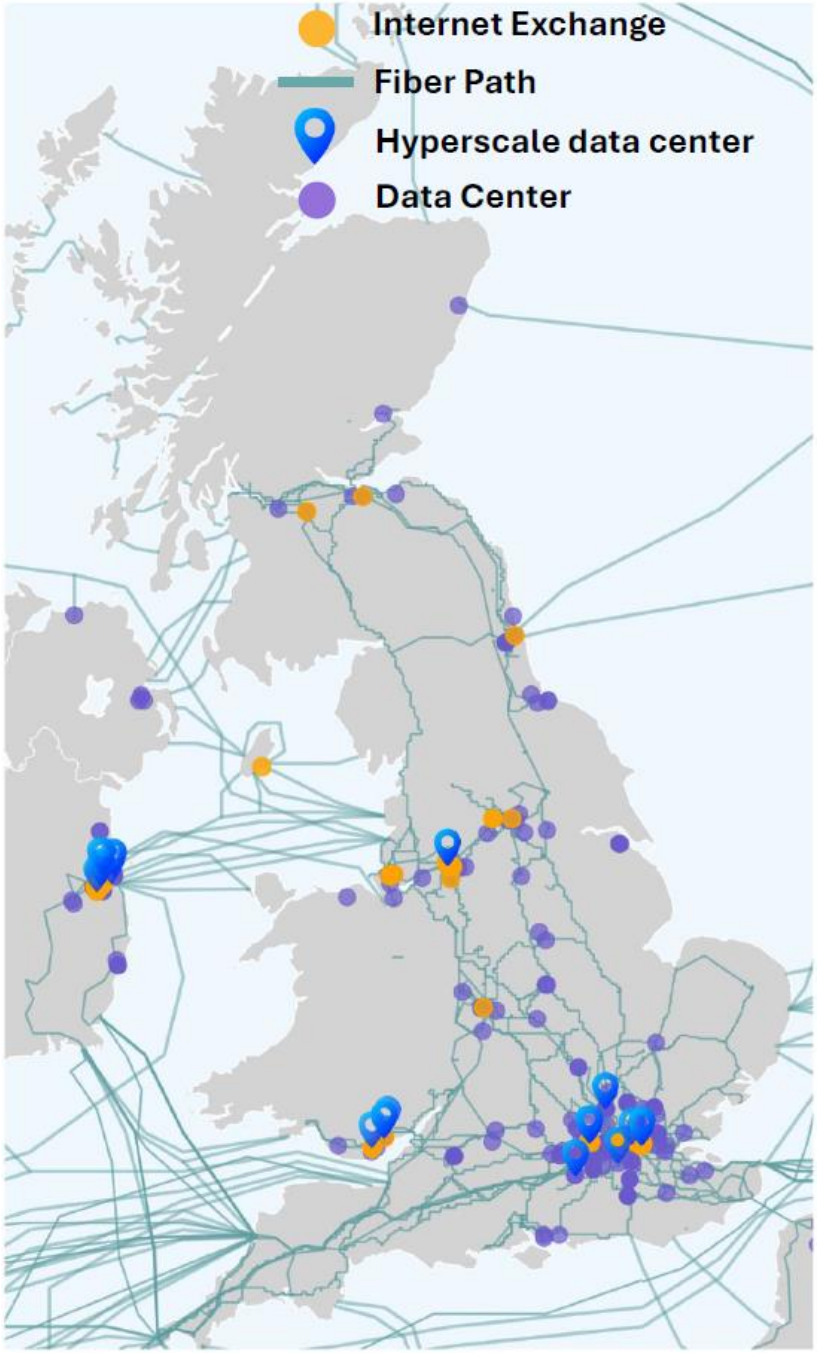


Figure 10. Map of network infrastructure to be delivered beyond 2030

Installed Capacities (GW)			
Technology	**2023**	**2030 Further Flex and Renewables**	**2030 New Dispatch**
Offshore wind	14.7	50.6	43.1
Onshore wind	13.7	27.3	27.3
Solar	15.1	47.4	47.4
Nuclear	6.1	3.5	4.1
Biomass/BECCS	4.3	4.0	3.8
Low carbon dispatchable power	0	0.3	2.7
Other renewables	4.7	5.7	5.7
Batteries	4.7	27.4	22.6
LDES	2.8	7.9	4.6
Interconnectors	8.4	12.5	12.5
Unabated gas	37.4	35.0	35.0

Data Centre

- Data centre demand in GB is estimated at 7.6 TWh from the 2.4 GW connected facilities, mainly for traditional services such as banking, which often requires close proximity to London. *
- We expect future data centres to be increasingly utilised for AI, which may result in less importance on location and latency issues, compared to the existing data centre fleet.*



"Layered Maps of the UK Data Centre(Shared by EPRI)"

* Future Energy Scenarios (FES) 2025, https://www.neso.energy/document/364541/download

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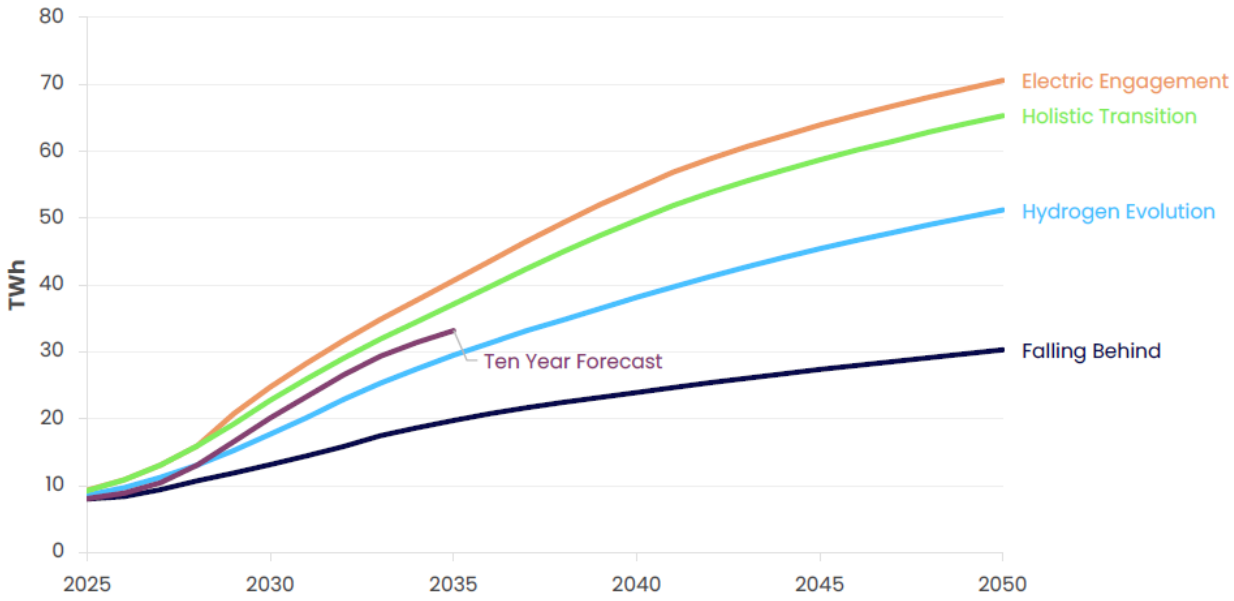

Electricity demand for data centres*

- Forecasted capacity 5-7G by 2030
- Currently more than 60G in connection queue

Modelling assumptions	Holistic Transition	Electric Engagement	Hydrogen Evolution	10 Year Forecast	Falling Behind
2035 electricity demand	37 TWh	41 TWh	30 TWh	33 TWh	20 TWh
2050 electricity demand	65 TWh	71 TWh	51 TWh	N/A	30 TWh
2050 connections	14.1 TWh	14.6 TWh	9.9 TWh	N/A	6.1 TWh

A list of key outputs from our FES 2025 models covering energy demand from data centres*

* Future Energy Scenarios (FES) 2025, https://www.neso.energy/document/364541/download

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Operability Challenges

- **Load potential of very short-term cycling or ramping** (seconds/mins) of DC load will also be important for frequency stability considerations and regulation reserve dimensioning

- **Sub-synchronous Oscillation**

- **Ride through performance:**
  - Could drive considerations for fault ride through requirements and ramping requirements for DC/large loads, or
  - Strengthening the grid to mitigate voltage disturbances and minimize load reduction during faults

Large Load Oscillations and Transients

Large Electronic Loads can vary their consumption relatively rapidly

Minutes

Seconds

Can cause frequency control issues, including exhaustion of Regulation Up/Down Ancillary Services

Sub-synchronous Oscillations

Generally, 1 to 30 Oscillations per second.

Sub synchronous

Transient-Like Behavior

- Can cause damage to grid equipment, including the shafts of synchronous generators

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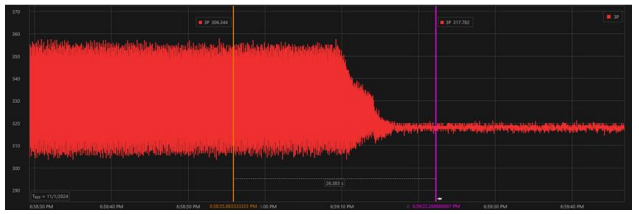
Past events:

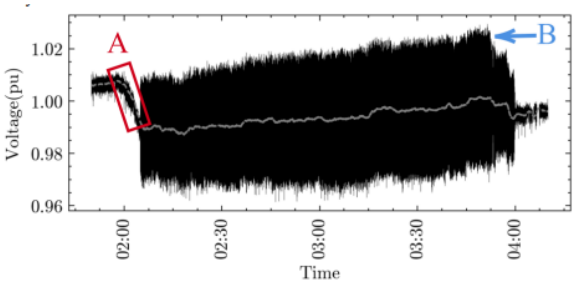
- ERCOT 23 Hz Event (July-October 2024)
  - ERCOT received PMU data (60 samples/sec) showing 23 Hz oscillation was present before load reduced and mitigated by reducing load consumption to 300 MW

https://www.ercot.com/files/docs/2025/02/28/LL-Oscillation_LFLTF_Mar2025_Final.pptx



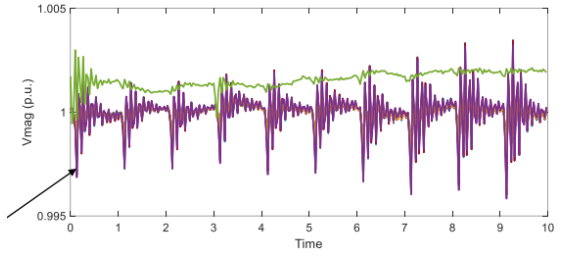
- Dominion Energy 14.7-14.8 Hz Event

https://www.researchgate.net/publication/389098360_Understanding_the_Inception_of_147_Hz_Oscillations_Emerging_from_a_Data_Center



- Dominion Energy 1-11 Hz Event

https://www.epri.com/events/539b60d7-57da-4252-9968-fb1754ee3b66



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Fault Ride Through Behaviour of Large Energy Users

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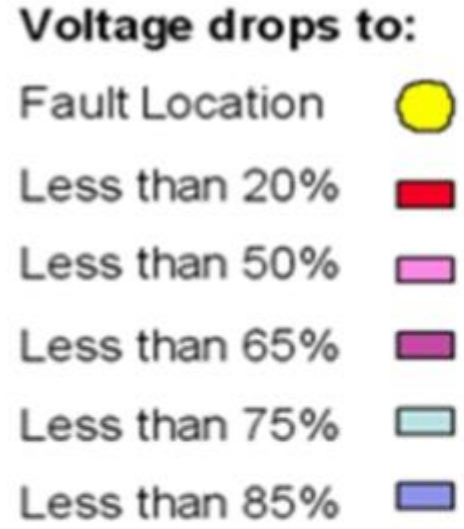
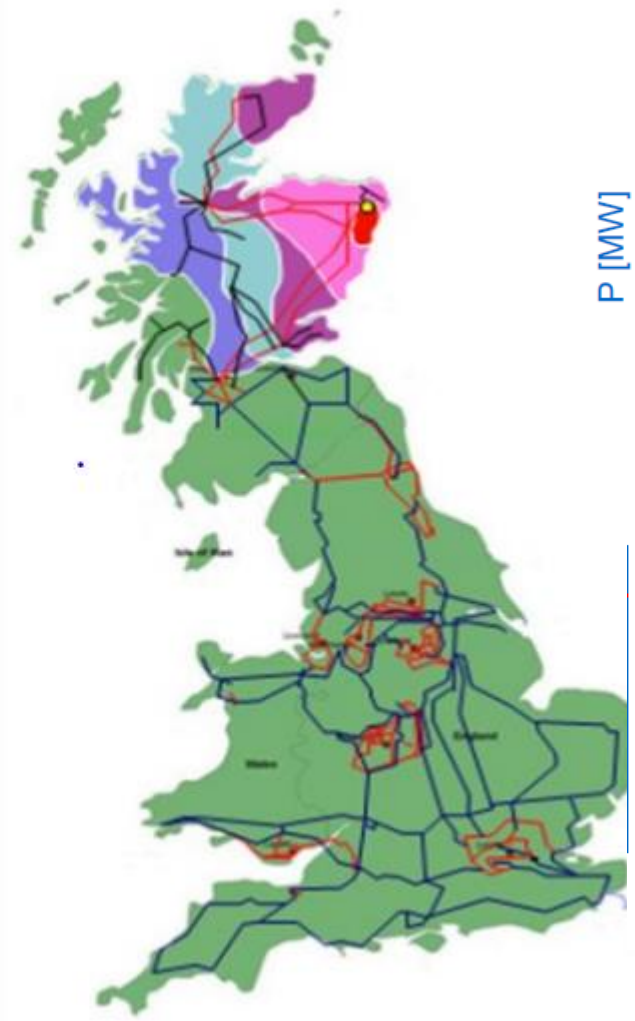
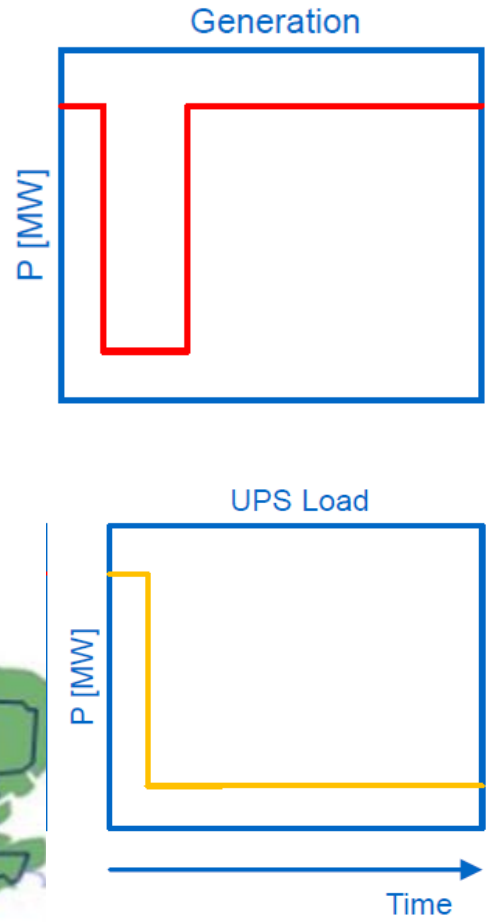
What is low voltage ride through

Step By Step :

- Transmission System Fault
- Voltage Dip
- Initial Generation and UPS Load Reduction
- Fault Cleared
- Generation Output Recovers UPS Load remains reduced
- Unbalance Power distribution results in elevated system frequency







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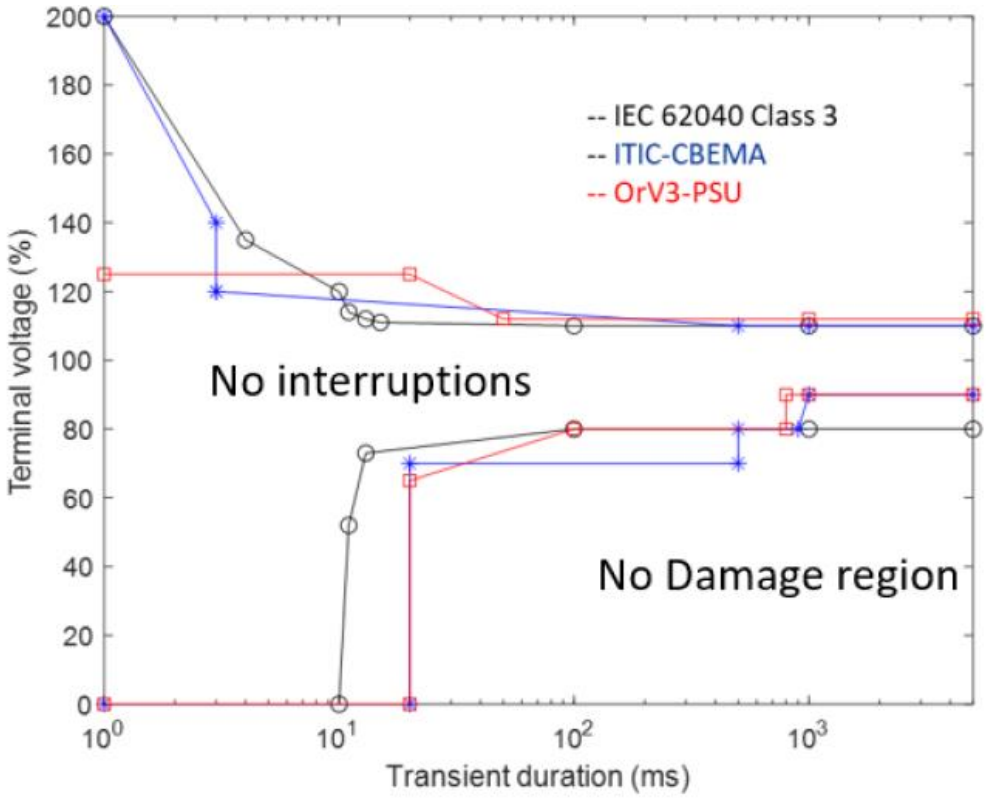
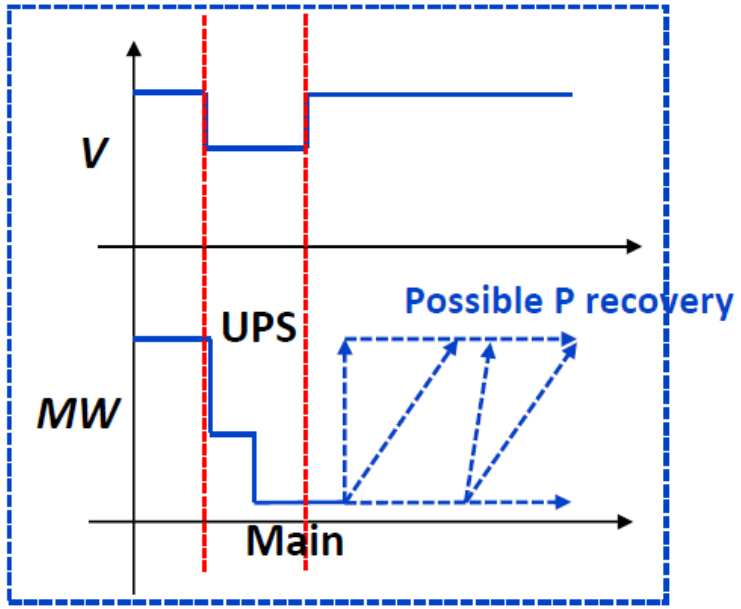
Ride-through performance specifications for UPS*



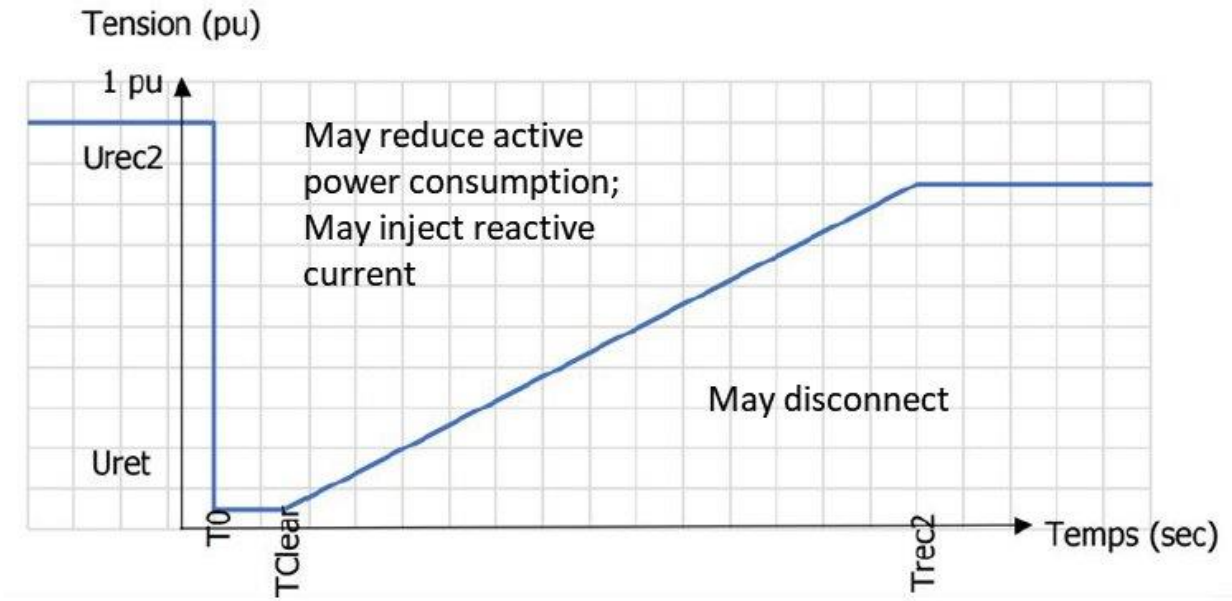
- **Multiple standards/specifications**
- **If the terminal voltage exceeds specified limits, the entire load may be disconnected from the grid to protect the equipment**

Voltage recovery:

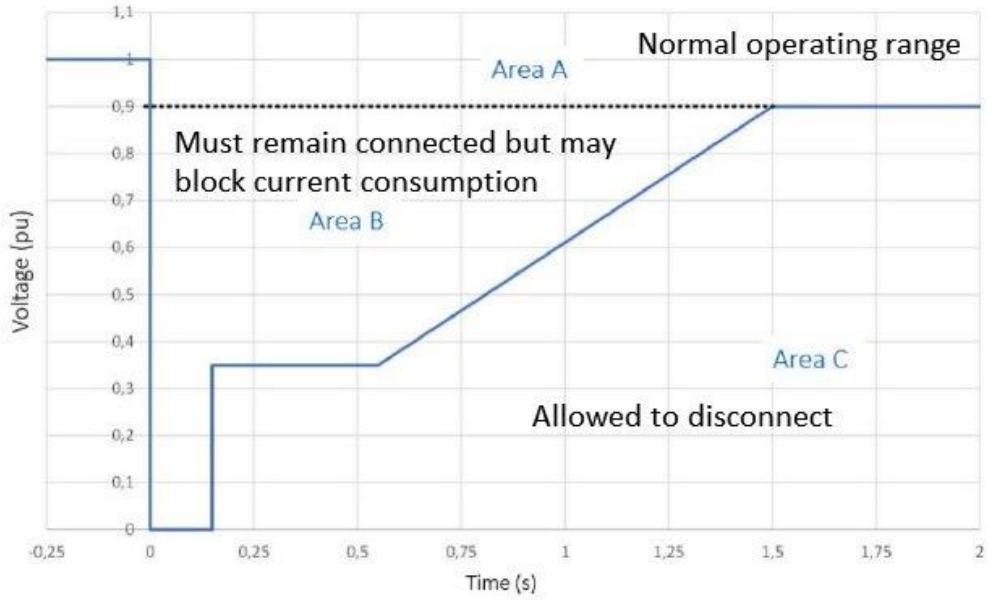
- **They may reconnect immediately**
- **They may reconnect after a delay**
- **They may reconnect after a delay with a slow ramp**



Different TSO ride through requirements



- **RTE requirement**



- **Energinet**

Different TSO ride through requirements

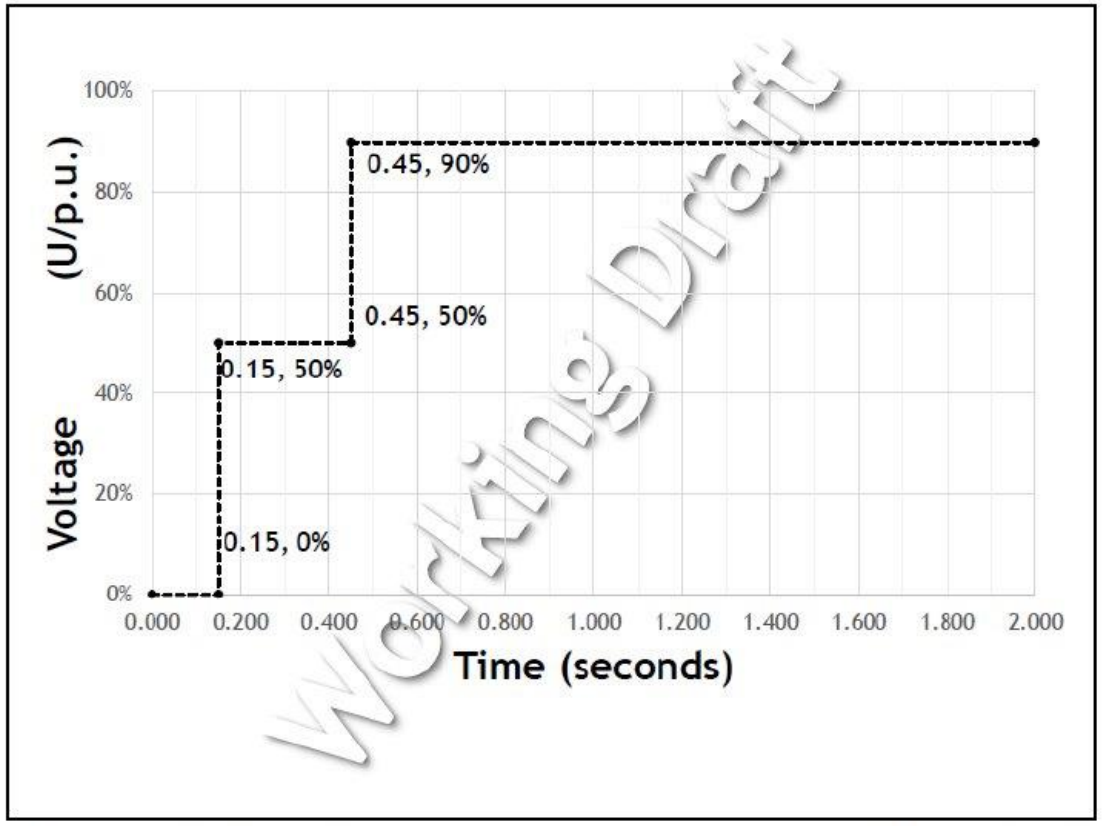
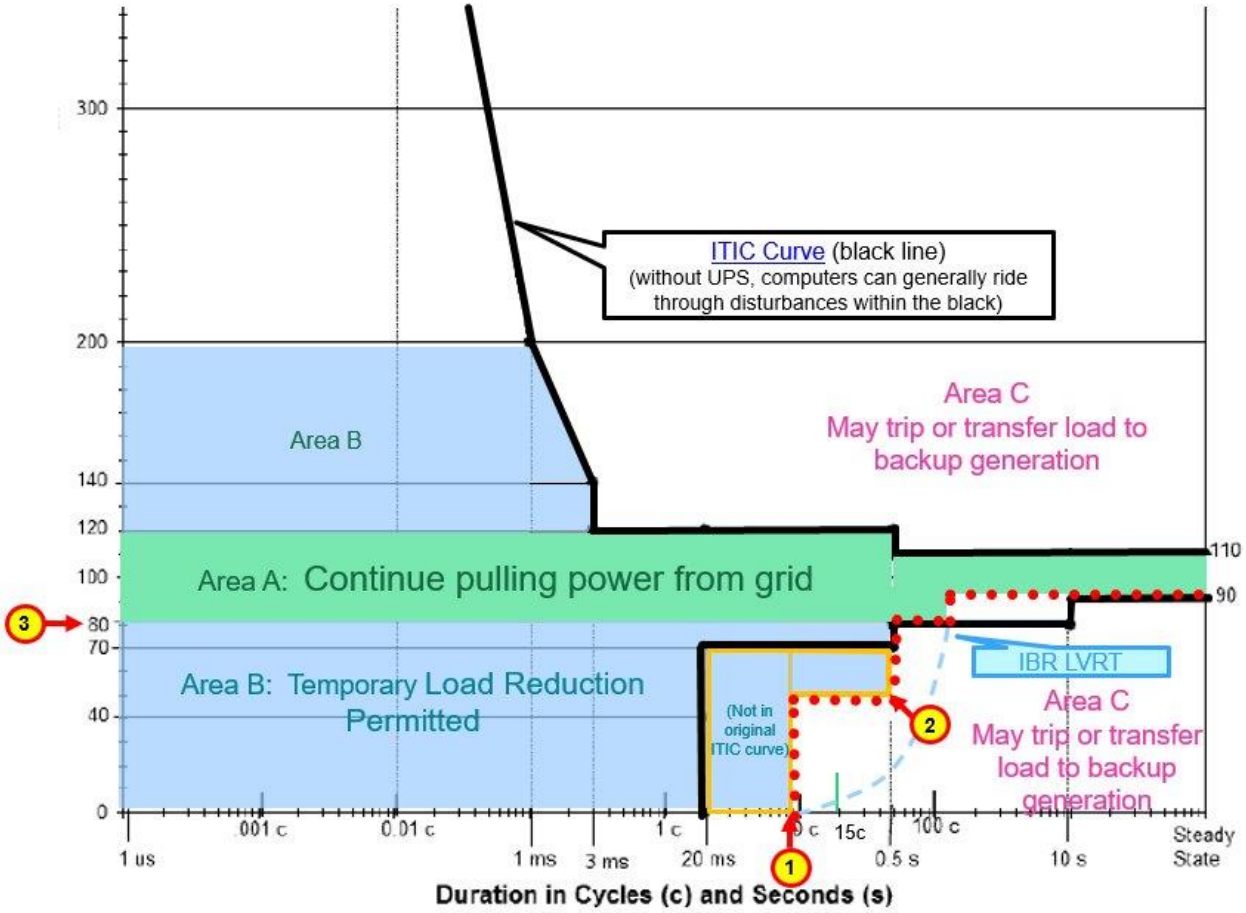


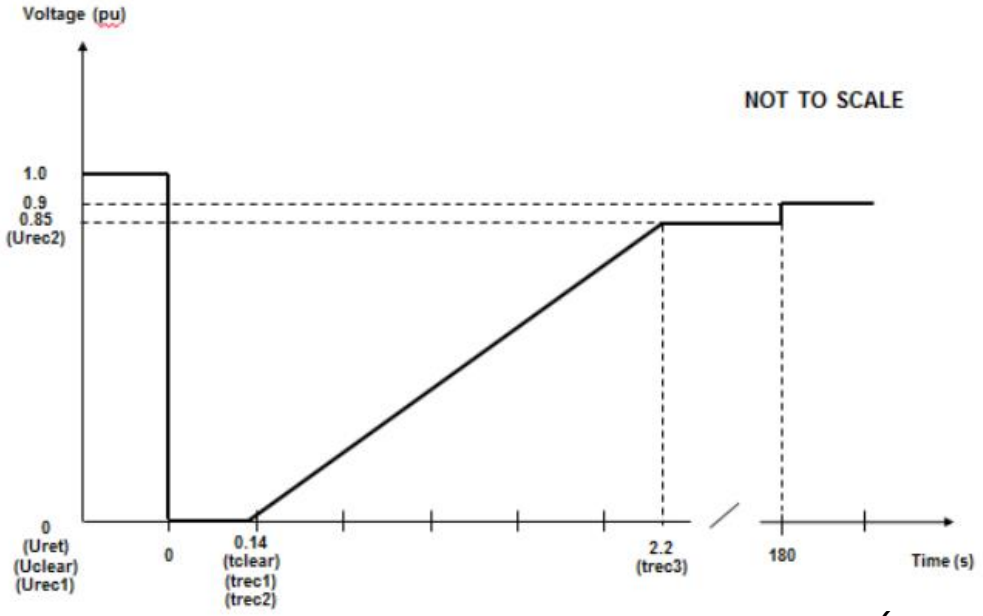
Figure 4. Potential fault ride-through requirements (watermark added by TSOs Task For

- **EirGrid proposal**

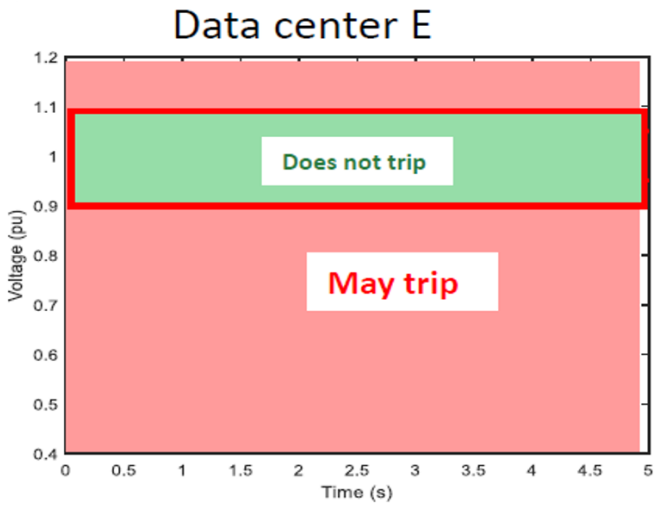


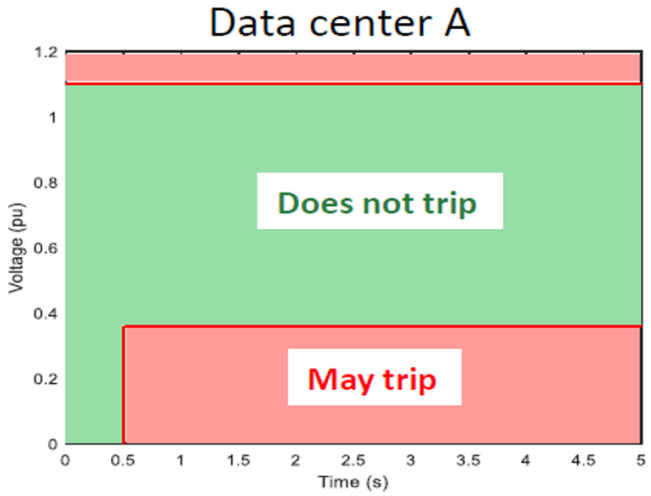
- **ERCOT proposal**

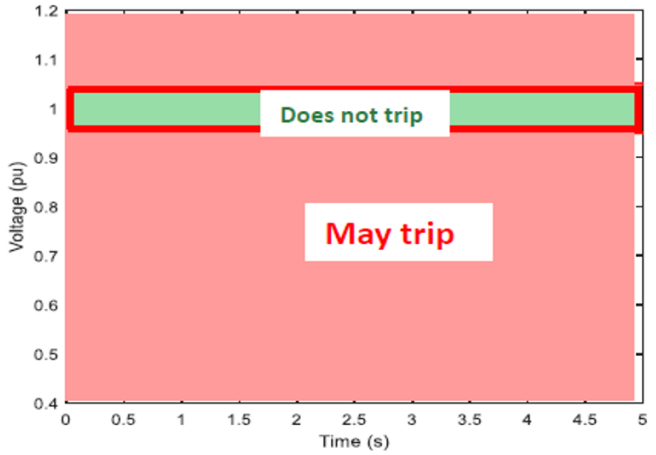
GB potential proposals

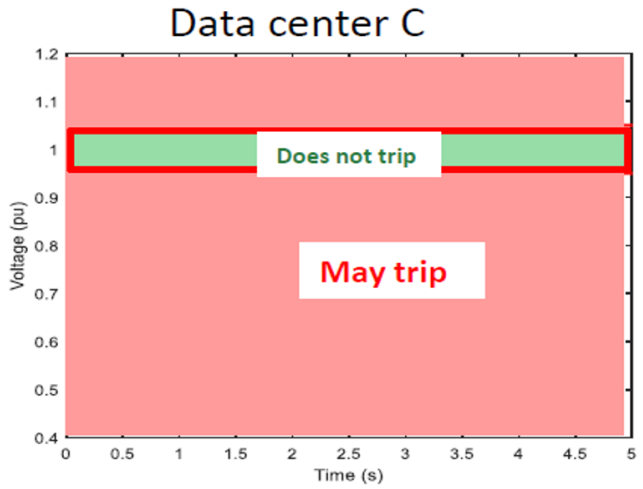


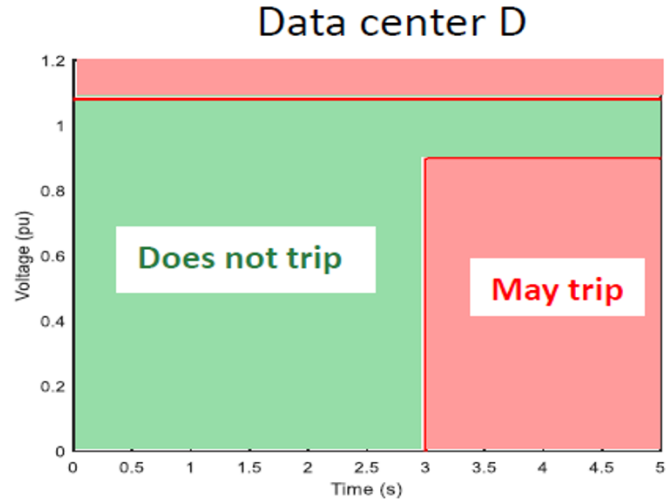
"FRT-non-embedded customers-Large load (NESO)"











 *Source: EPRI Hyperscale data centres project

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Thank You!

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