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And It's Gone: The Impact of Data Centres on Demand During Voltage Excursion

Data Centre Growth: A Power Hungry Future

4%

UK Now

Current percentage of total UK energy demand from data centres

6%

UK by 2030

Projected percentage of total UK energy demand from data centres

2%

Europe Now

Current percentage of total European energy demand

5%

Europe by 2030

Projected percentage of total European energy demand

The Open Compute Project is developing specifications for AI data centres with rack densities up to **1MW**.

Data centres are unique as they have **100% generator backup**.

How Do Voltage Excursions Trigger Backup Generation?

Understanding Voltage Excursions

Voltage dips (sags) and swells are temporary fluctuations in the electrical grid, where the root mean square (r.m.s) voltage either drops below or rises above a specified threshold. These momentary deviations can disrupt sensitive equipment in data centers.

Protection Mechanisms

- **Overvoltage and Undervoltage Relays:** Common in Europe, these relays detect and respond to significant voltage variations.

- **Power Quality Monitor (PQM):** PQMs continuously monitor the grid for sags or swells, providing real-time data and triggering protective measures.

Normal Operation

The data center operates on grid power with stable voltage supply.

Voltage Disturbance Detected

A voltage dip or swell is identified by the protection systems, initiating the automatic start of backup generators.

Generators Reach Nominal Values

Backup generators quickly spin up and stabilize at their operational voltage and frequency levels.

Transition to Generator Power

The data center disconnects from the grid and transfers to the backup generators. This entire process typically takes less than 30 seconds.

Utility Challenge: Dominion Energy Case Study

1

10th July 2024

Surge arrestor on 230kV line failed, locking out transmission line

2

Six reclose attempts

Over 82-second period due to auto-reclosing control configuration were registered as voltage disturbances at the DC

3

~1500MW load reduction

Data centres switched to backup generators after three voltage disturbances within 60 seconds

4

Grid impact

Frequency rose to 60.047 Hz, voltage increased to 1.07 p.u.

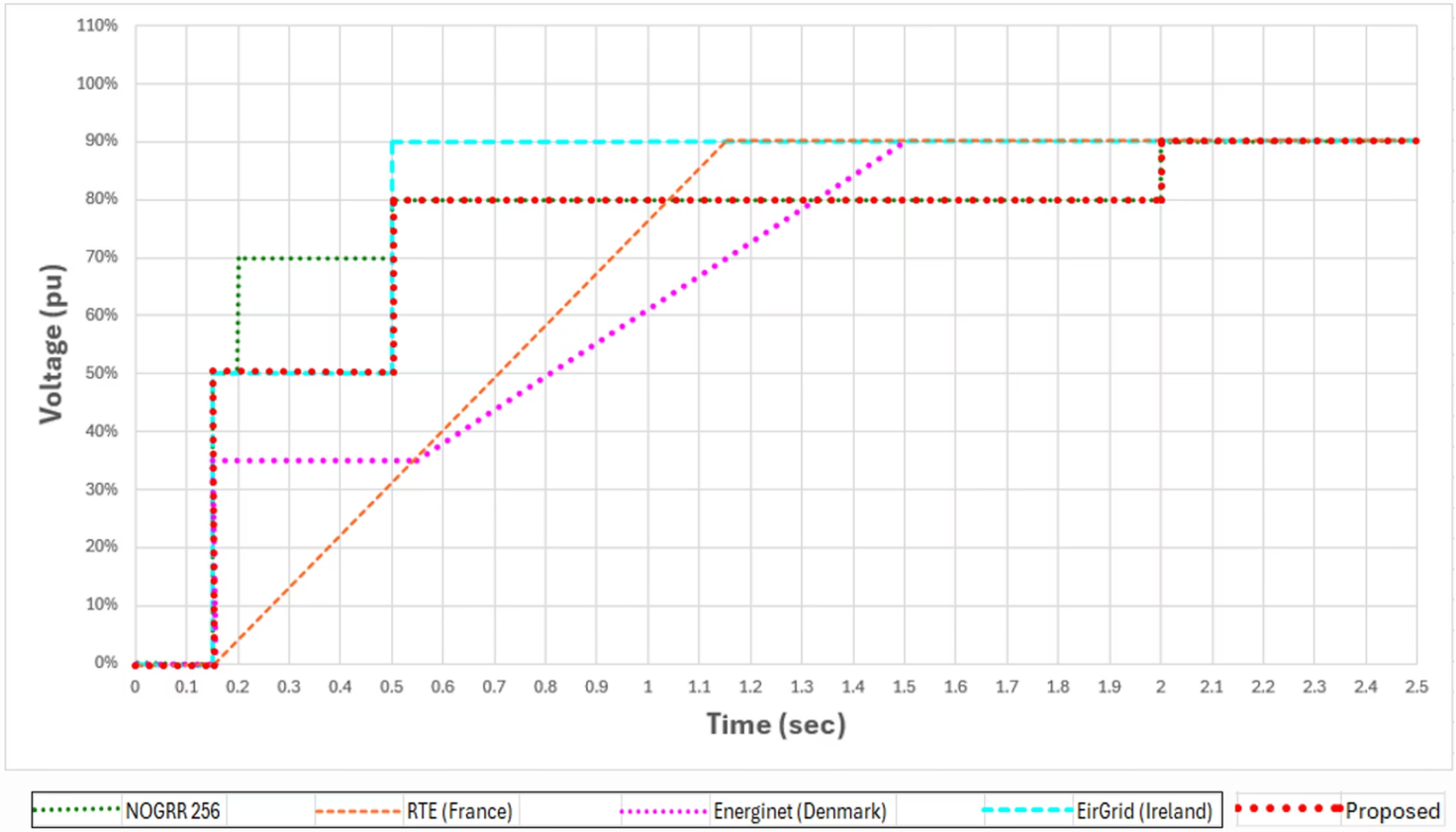
Utility Response: Fault Ride Through Requirements

To counteract this issue, utilities have begun implementing:

- Fault Ride Through (FRT) requirements for demand facilities
- Post Fault Active Power Recovery (PFAPR) requirements

Challenges:

- FRT not harmonised across utility providers
- More focus on LVRT than HVRT requirements
- Equipment manufacturers require time to implement and test FRT and PFAPR behaviour



Challenges for Data Centre Providers

1 **Grid Code Limitations**

Not all utilities have FRT and PFAPR requirements for demand

2 **Protection Settings**

Can be adjusted to align with utility requirements, but impacts on downstream equipment needs to be assessed

3 **Equipment Immunity**

IEC 61000-3-34 equipment immunity testing is lower than utility FRT requirements

4 **Harmonisation**

Different utilities have different FRT requirements making it difficult to assess the impact on data centre operations

During a voltage disturbance:

- IT loads with UPS remain online (supplied via battery) - this demand will be disconnected from the utility
- Larger mechanical loads (chillers) with VSDs lack energy storage, causing DC bus to trip on undervoltage - this demand will be disconnected from the utility

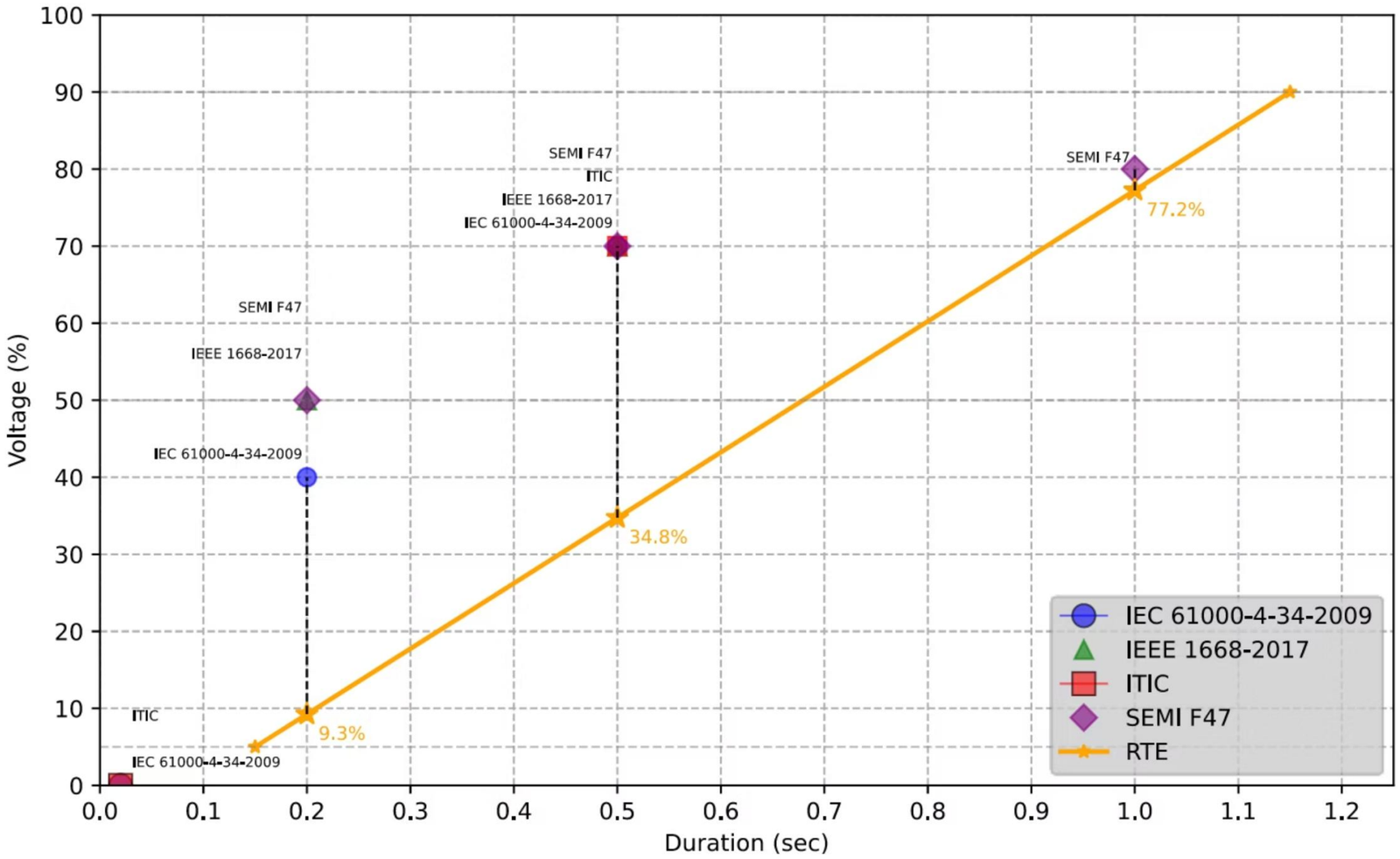
Immunity Testing Comparison - LVRT

Comparison of immunity testing standards against RTE (France) LVRT requirements for demand

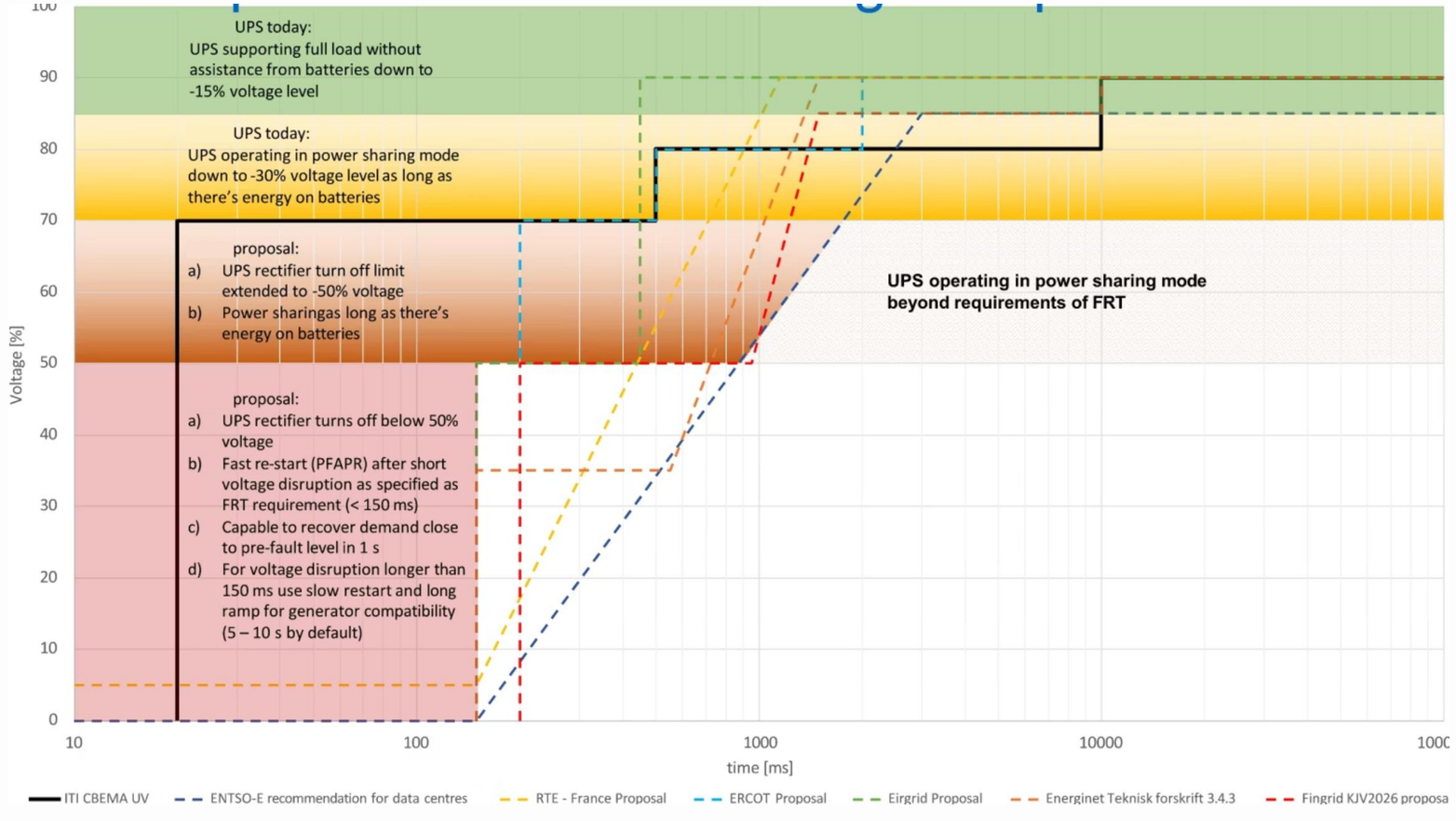
Current immunity testing standards are less onerous that utility FRT requirements

Equipment will either:

1. Disconnect and continue operating from battery if UPS backed
2. Shutdown which is a loss of demand on the utility



UPS Behaviour During Voltage Disturbances



1

<15% Voltage Dip

Loads supplied via UPS using utility supply

2

15-30% Voltage Dip

Power sharing between batteries and utility

3

30-50% Voltage Dip

Power sharing (development required)

4

>50% voltage dip

Rectifier turns off, loads supplied from battery

This example from a single UPS manufacturer is still in development. Clear guidance required to ensure FRT and PFAPR requirements are included in specifications for the tender and procurement process.

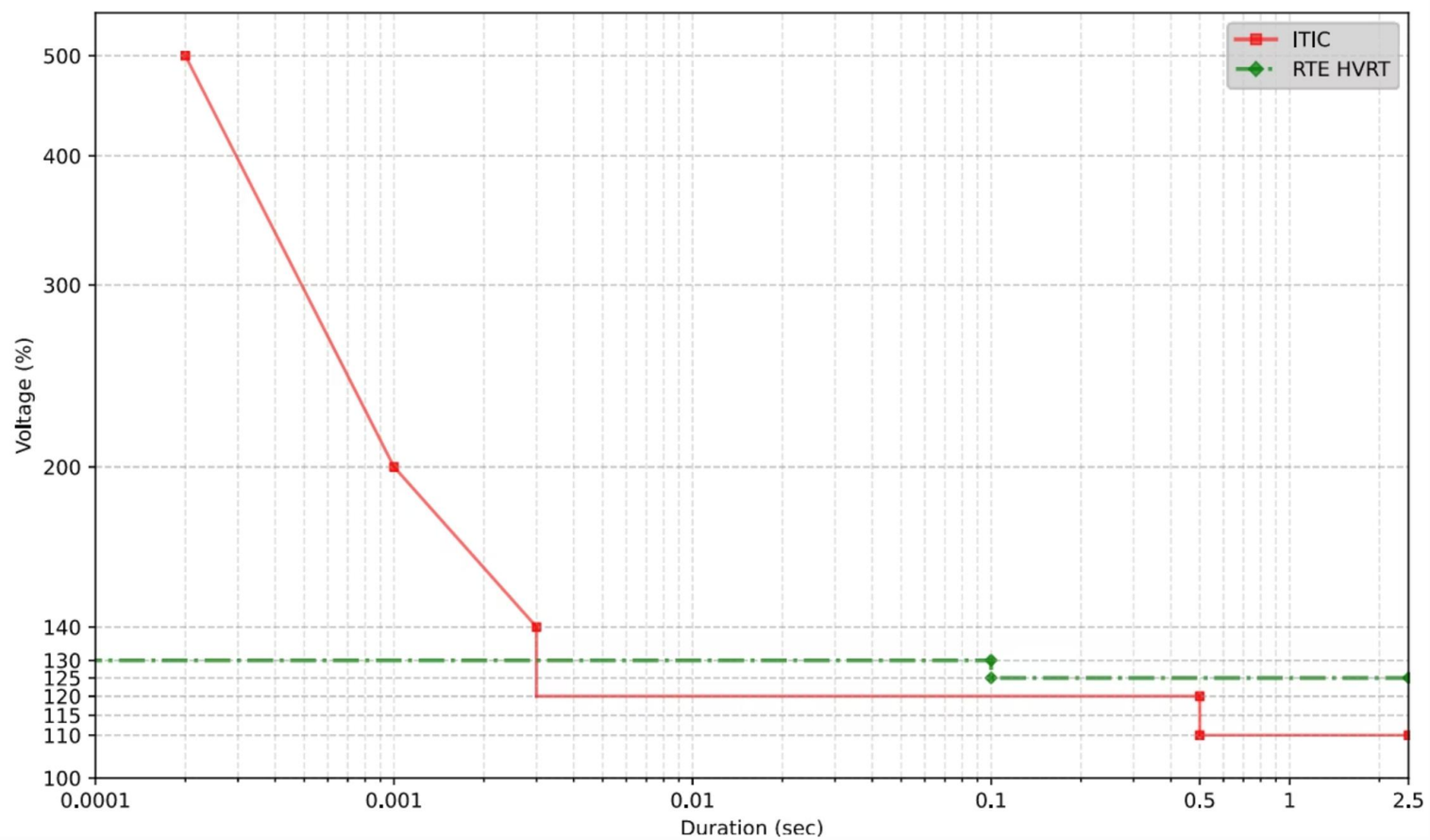
Immunity Testing Comparison - HVRT

Immunity and testing standards for HVRT are less common with the ITIC curve widely recognised.

RTE HVRT operates in the prohibited region of the ITIC curve (>3ms)

Equipment will either:

1. Disconnect and continue operating from battery if UPS backed
2. VFD's will disconnect for protection
3. Unprotected equipment may be damaged if not disconnected at the utility incomer



Takeaways and Points for Discussion

Balancing Protection & Stability

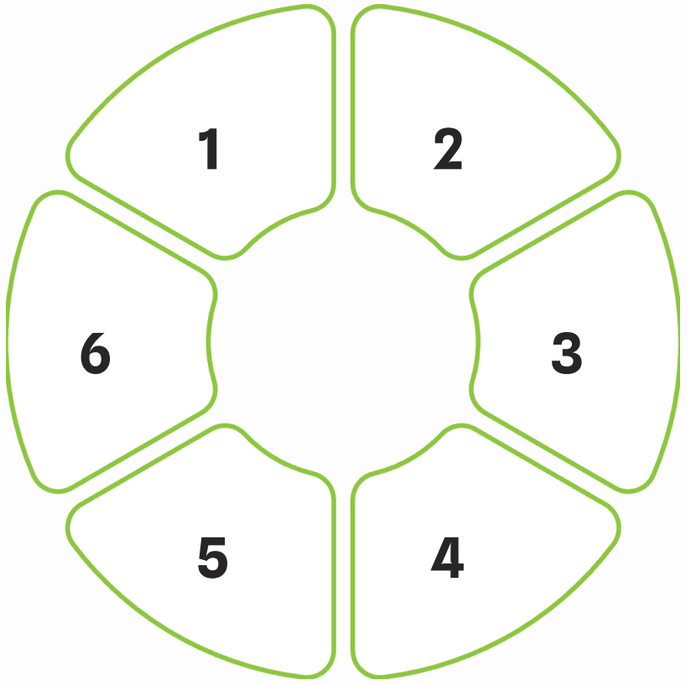
FRT requirements should take into consideration equipment limitations

Application Criteria

How are utilities applying these requirements? Blanket application to all data centres? Based on connection capacity or a data centre density demand threshold?

Timelines

Are all utilities that haven't yet, planning on issuing similar guidance?



Alignment

Between FRT requirements, immunity testing standards and the ITIC curve. Also between utilities and data centre providers (IEEE PES-TR 131 May 2025)

Stakeholder Consultation

Are FRT requirements determined in conjunction with equipment/manufacturer limitations?

Concessionary Period

To enable manufacturers data centre providers to meet utility FRT and PFAPR requirements

References

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- IEEE Power & Energy Society: Data Center Growth and Grid Readiness (PES-TR 131)
- Energinet: Technical Regulation 3.4.3 Requirements for Transmission-Connected Demand Facilities
- RTE: Article 8.3.5 - Specifications of the constructive capacities of a consumption installation *[Cahier des Charges des capacités constructives d'une Installation de consommation]*
- ERCOT Large Load Working Group

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