SIEMENS energy

Impact of AI Workload and E-Statcom as a Mitigation Measure

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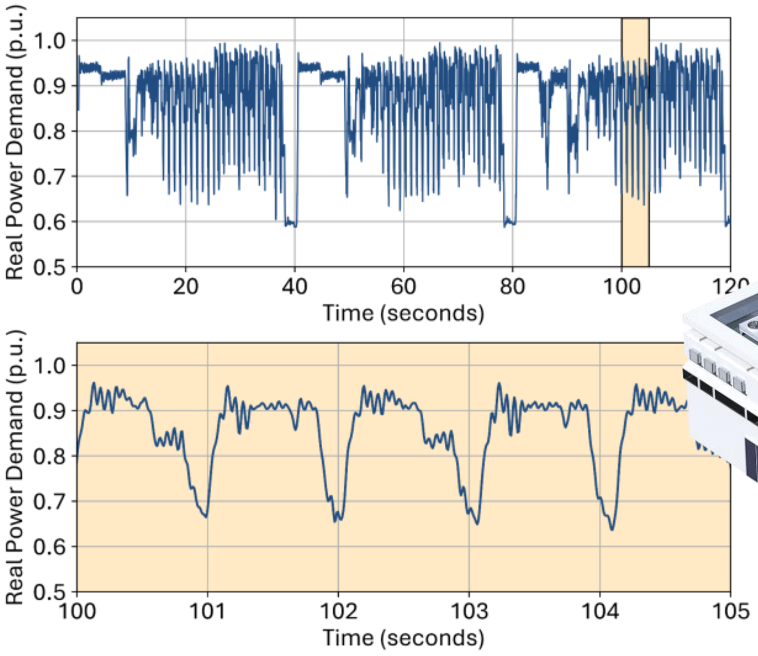
AI-training datacenter load pattern

If no mitigation measures put in place such load might damage the nearby electrical equipment (such as generators and turbines at the power plant)

Negative concerns on the nearby generators:

- Torsional resonance
- Local mode oscillations
- Might lead to unavailability due to poor operational behavior
- Premature Component damage

AI datacenters exhibit unique power consumption patterns, with rapid load transitions—shifting from idle (~40%) to full load (100%) and back within fractions of a second.
This is a behavior that no other load has done before.



AI Data Center

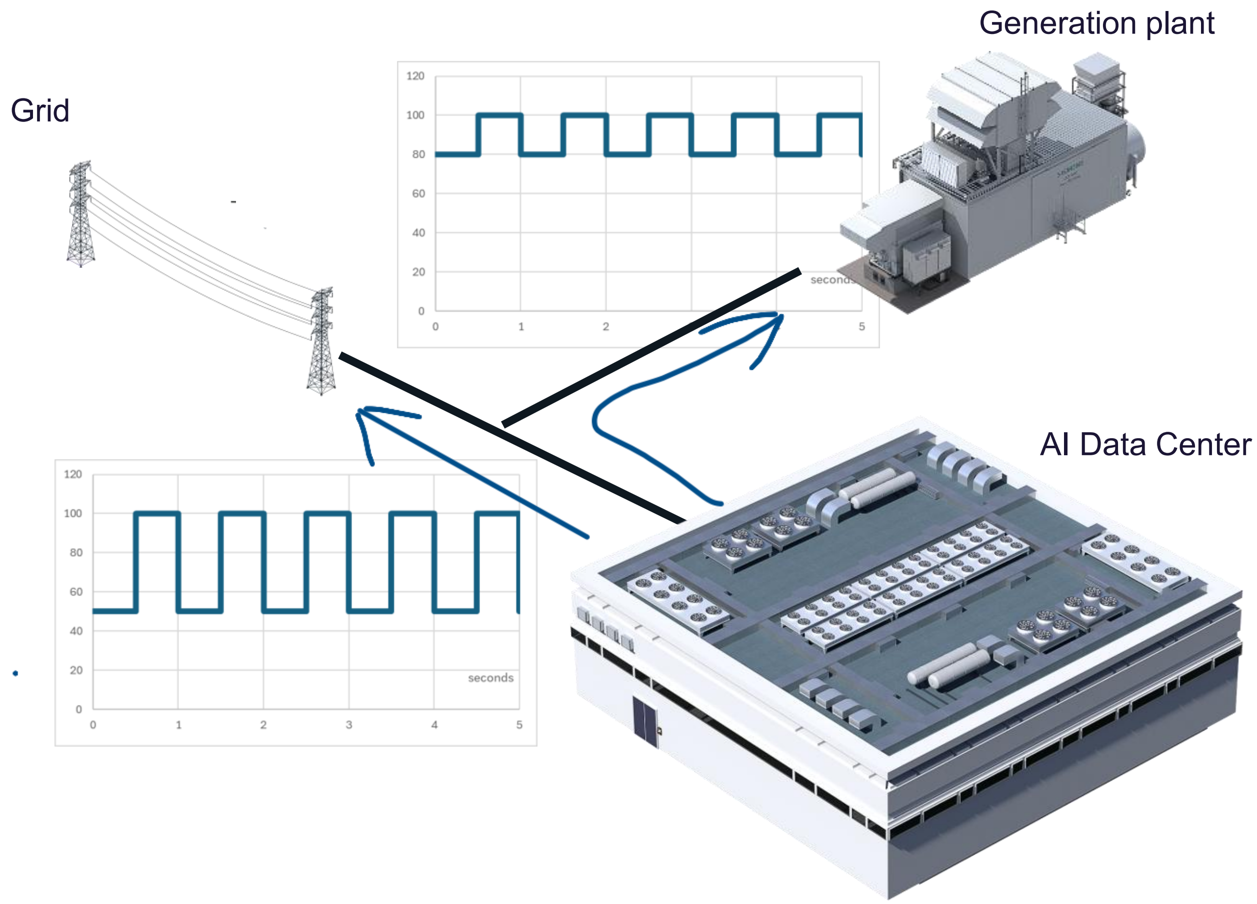
Source: NERC White Paper: Characteristics and Risks of Emerging Large Loads

If not addressed load fluctuation will enter the gen-set.

Depending on the magnitude and frequency of the fluctuation it might cause control malfunctioning, frequent unintended trips, and ultimately damage to critical components, and significantly reduce the expected life-time

Consistent fluctuations are significant risk to the gen-set

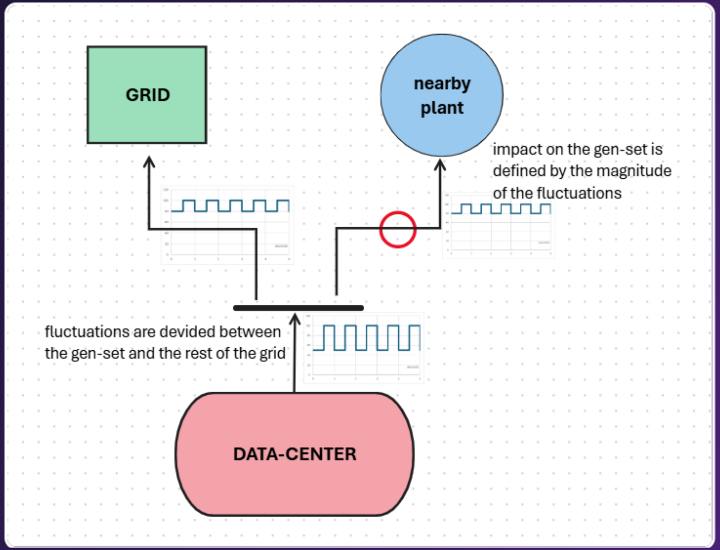
How fluctuating load impacts nearby plant?

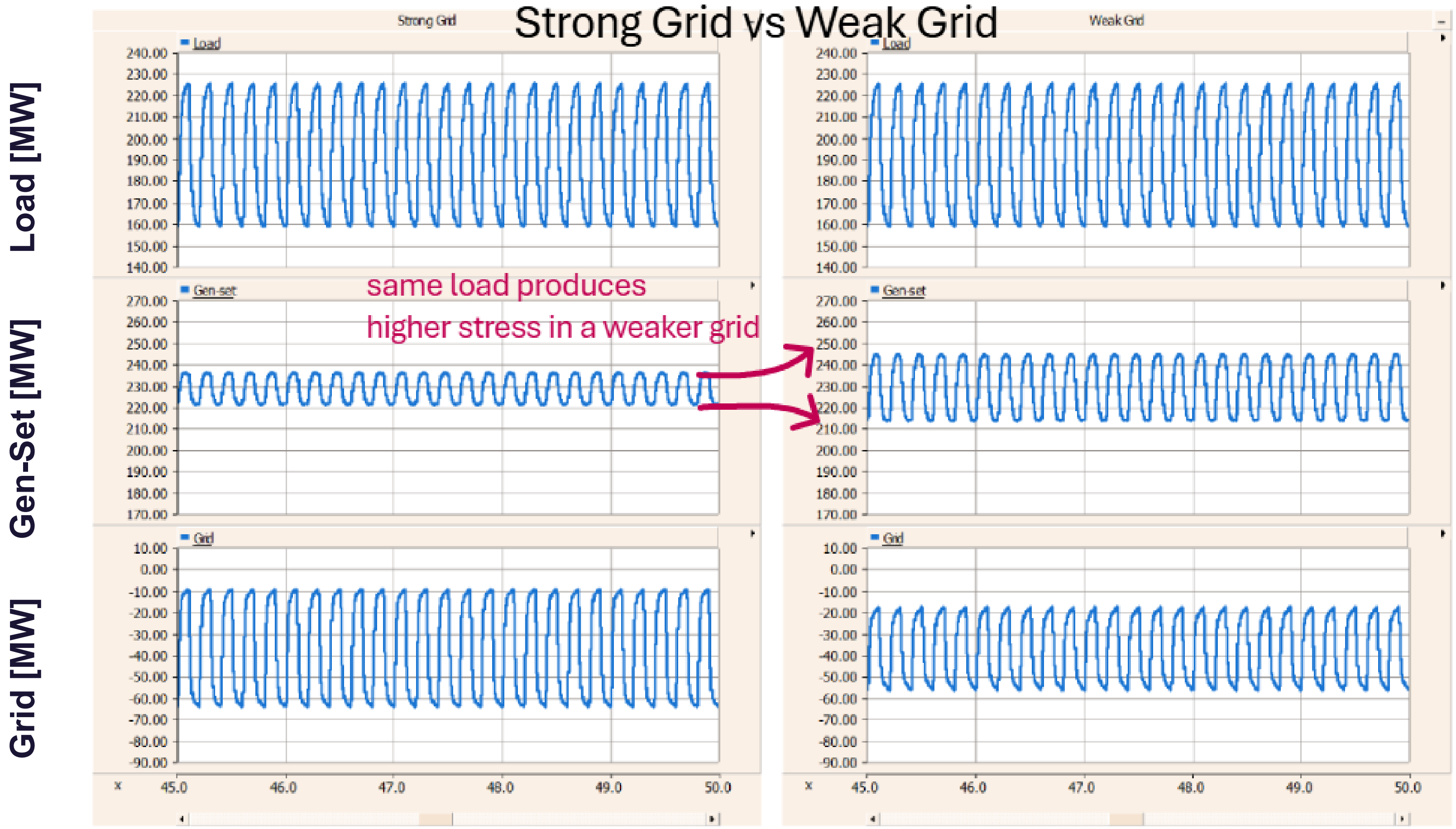


Major factors:
1. Strength of the grid

The fraction of a fast load disturbance ΔP that appears at the generator terminals depends on the grid configuration.

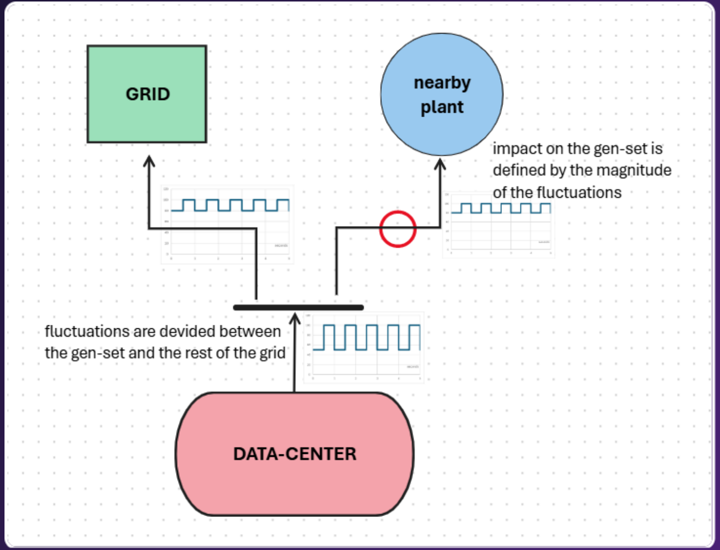
Hence a generator tied to a weak grid can see up to 2-3 times of the data-center fluctuation compared to the same unit on a strong grid.

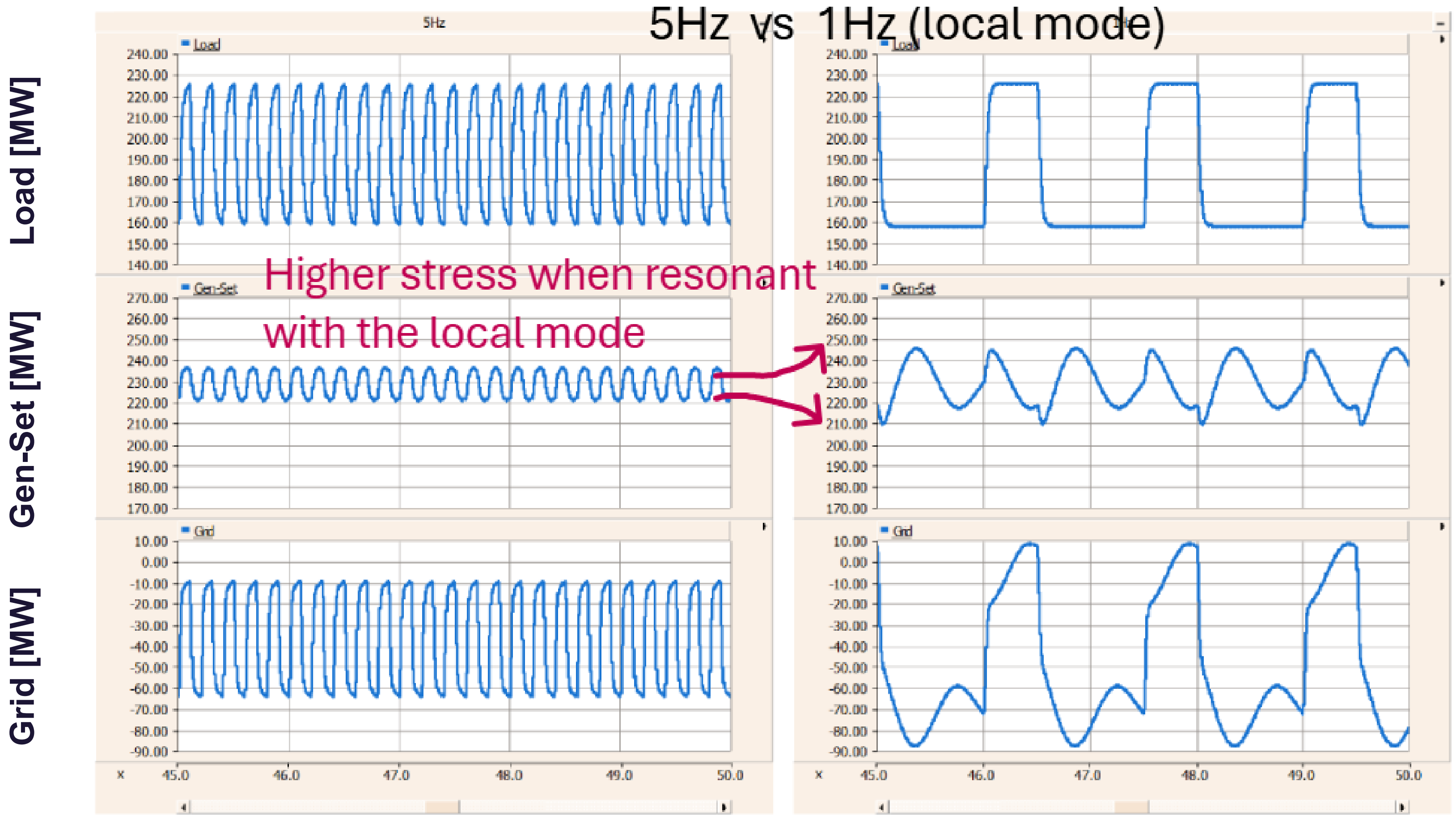




Major factors:
2. Frequence of the disturbance

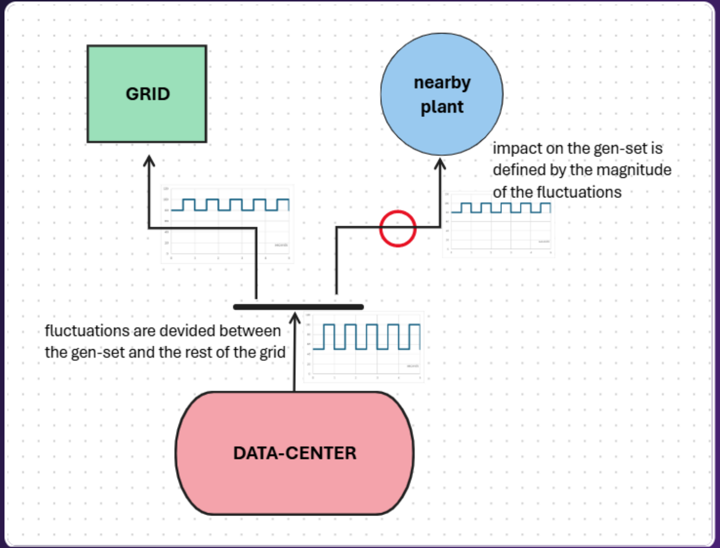
If the forcing frequency coincides with local mode (typically 0.5-2Hz), the generator can resonate with the grid, magnifying the oscillation by up to 50 % even when the external SCR is high.

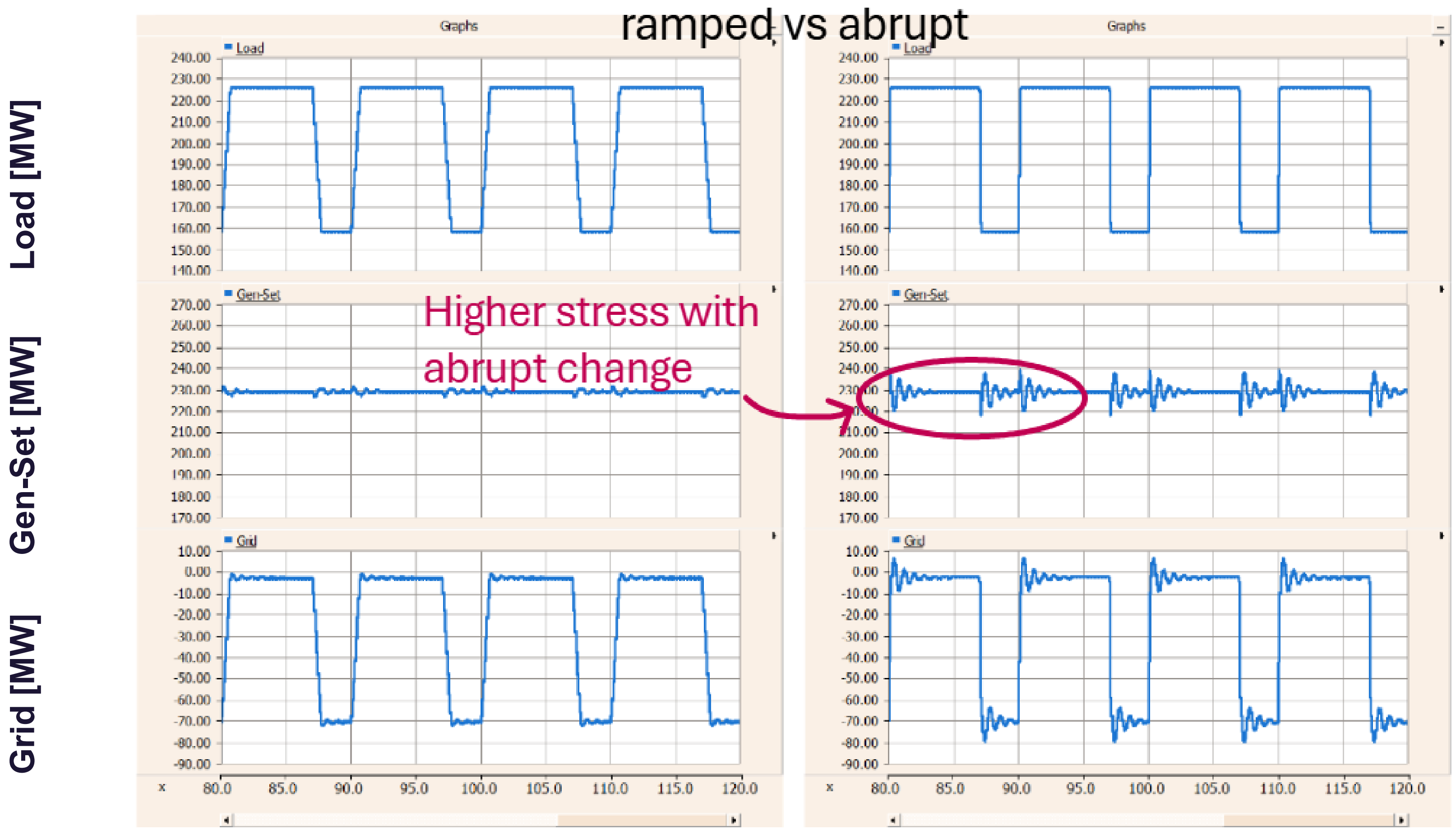


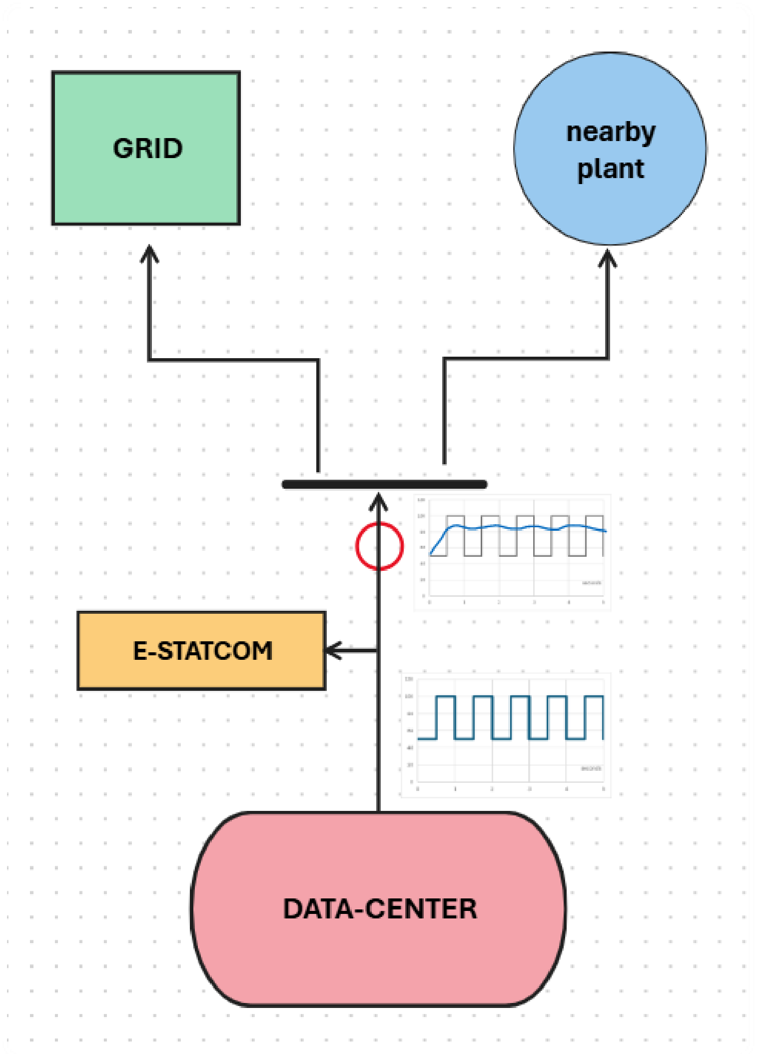


Major factors:
3. Ramp of the change

A step change forces large sub-transient currents; the same load change delivered as a ramp (e.g. dP/dt ≤ ~10 %/sec) produces only small additional current and torque, since the machine impedance can now be represented by the larger synchronous reactance Xd.







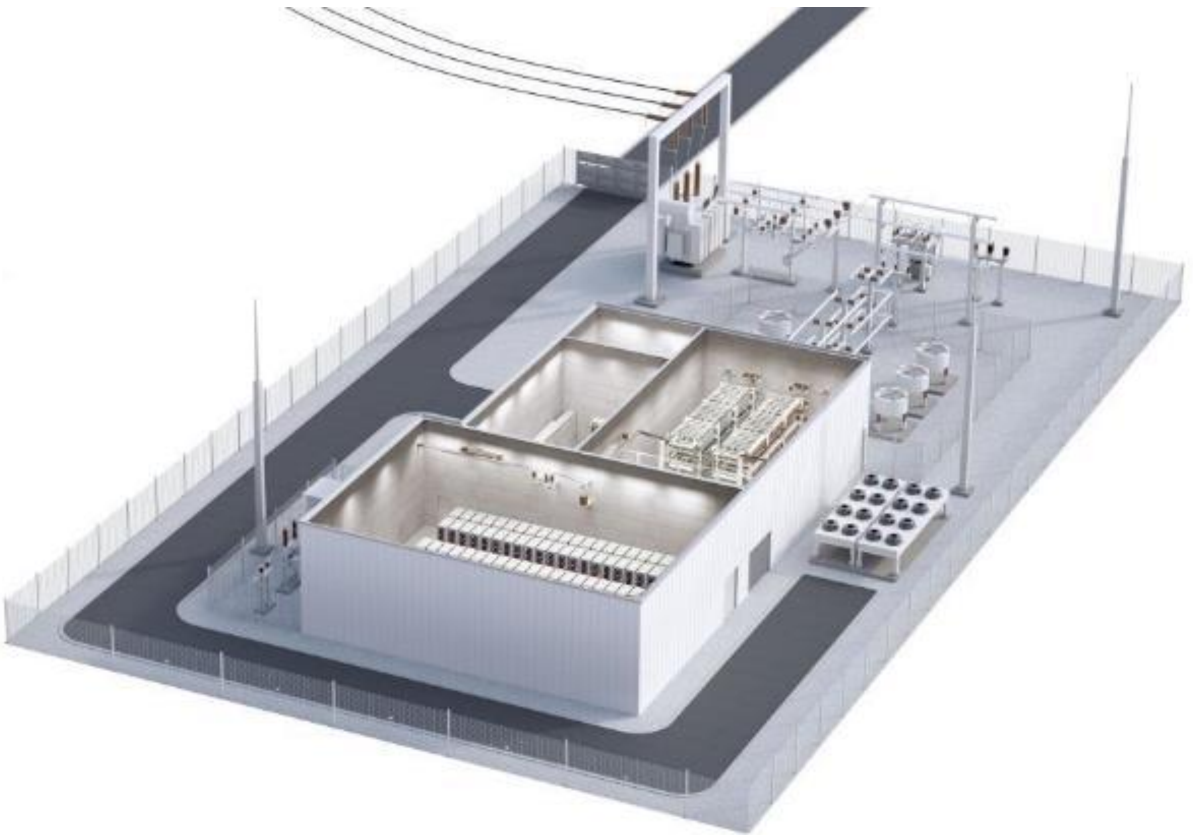
How to mitigate the risk to the nearby plant

The most effective way to mitigate the risk is to provide an energy buffer – adding an E-STATCOM at data center facility

The overall fluctuation must be reduced, such that the impact on the generator is neglectable, for example magnitude of the fluctuations are <1-2% * at the machine terminals

** 1-2% is a suggestive figure and can depend on individual shaft train's design and configuration and can vary by application*

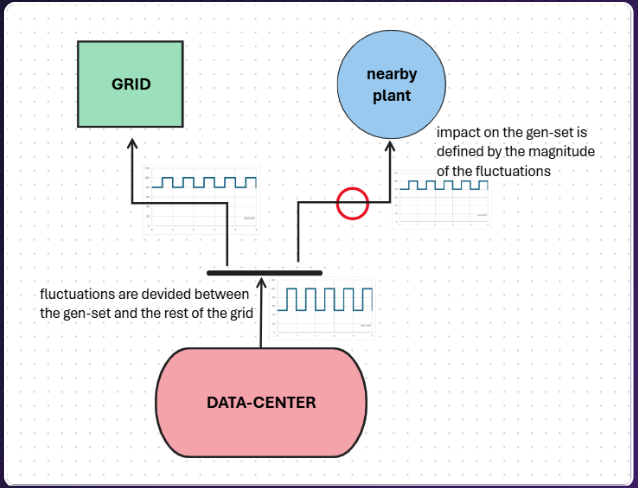
E-STATCOM for AI Datacenter load fluctuation

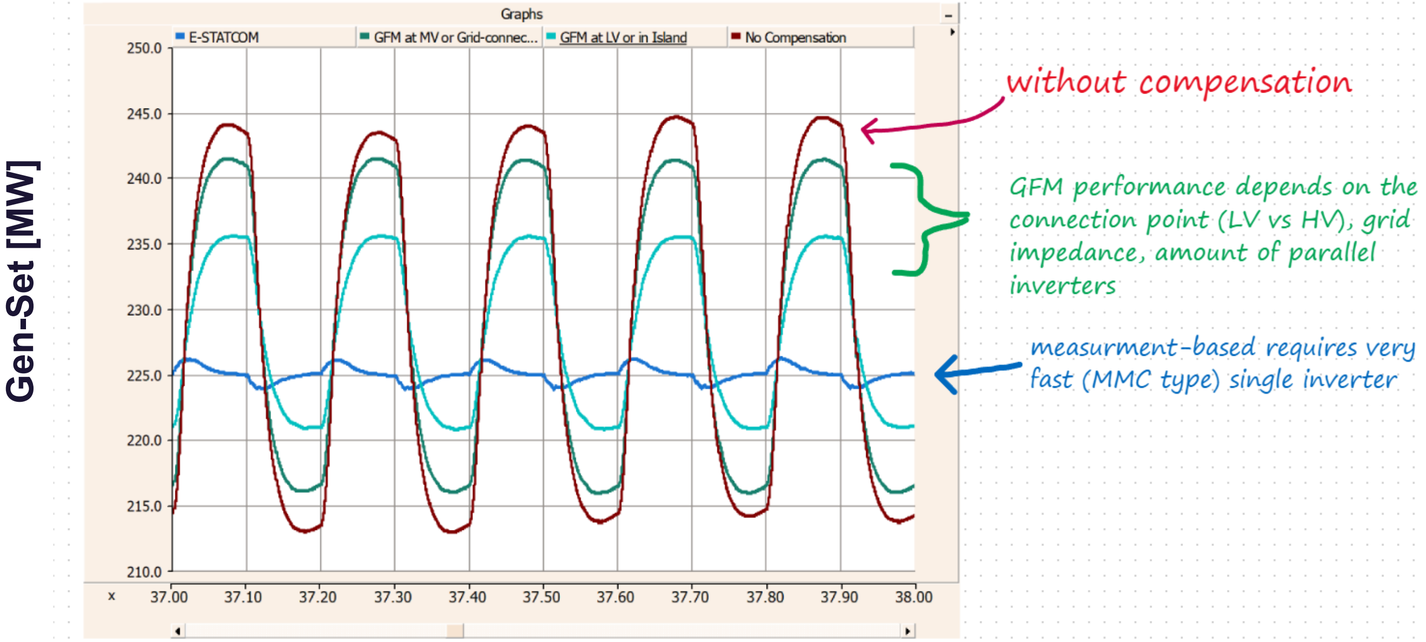


Product	SVC PLUS FS (Siemens Energy)
Active power	+/-75MW
Reactive Power	+/-75MVAR
System Voltage	34.5kV or higher
Response time	- <5ms
Special Features	- Variable Load Compensation - Fault-ride through support - Reactive Power Compensation - Voltage control

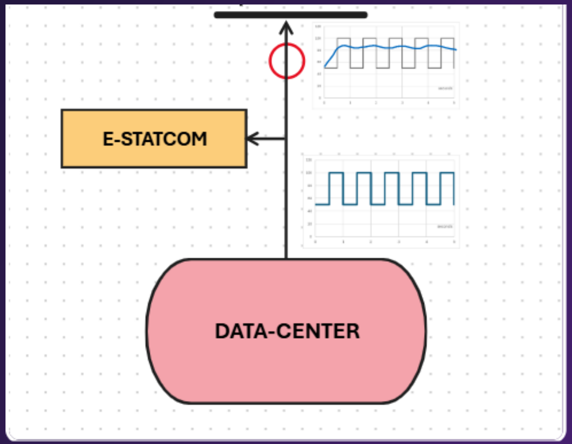
Very fast response time is critical for load compensation

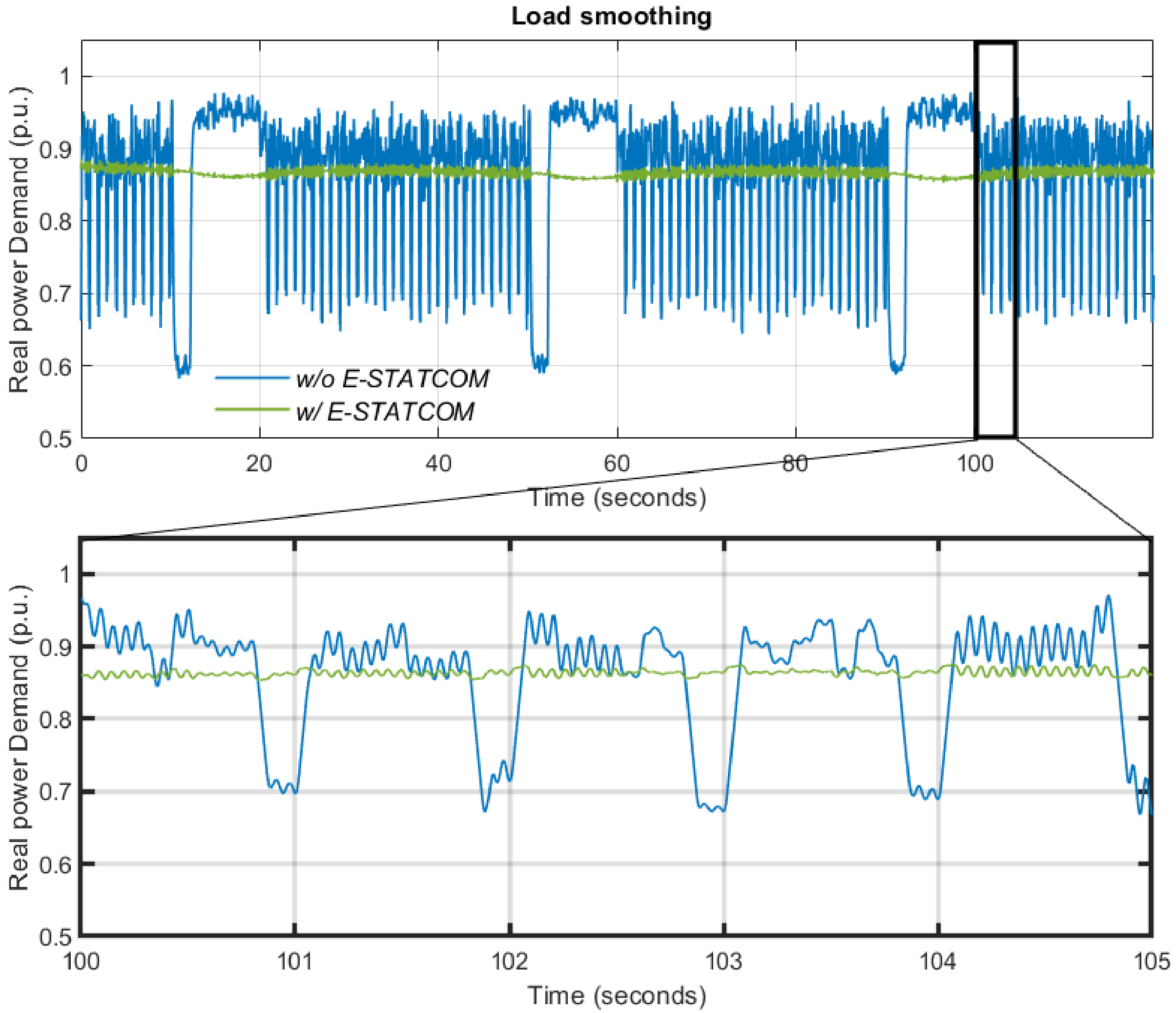
Grid-Forming vs Measurement-based approach





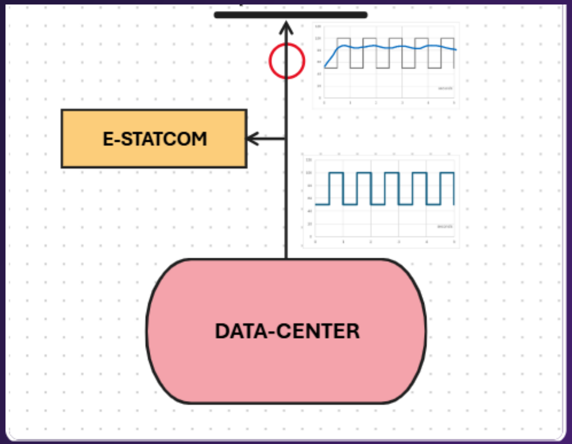
Example. Based on NERC Report

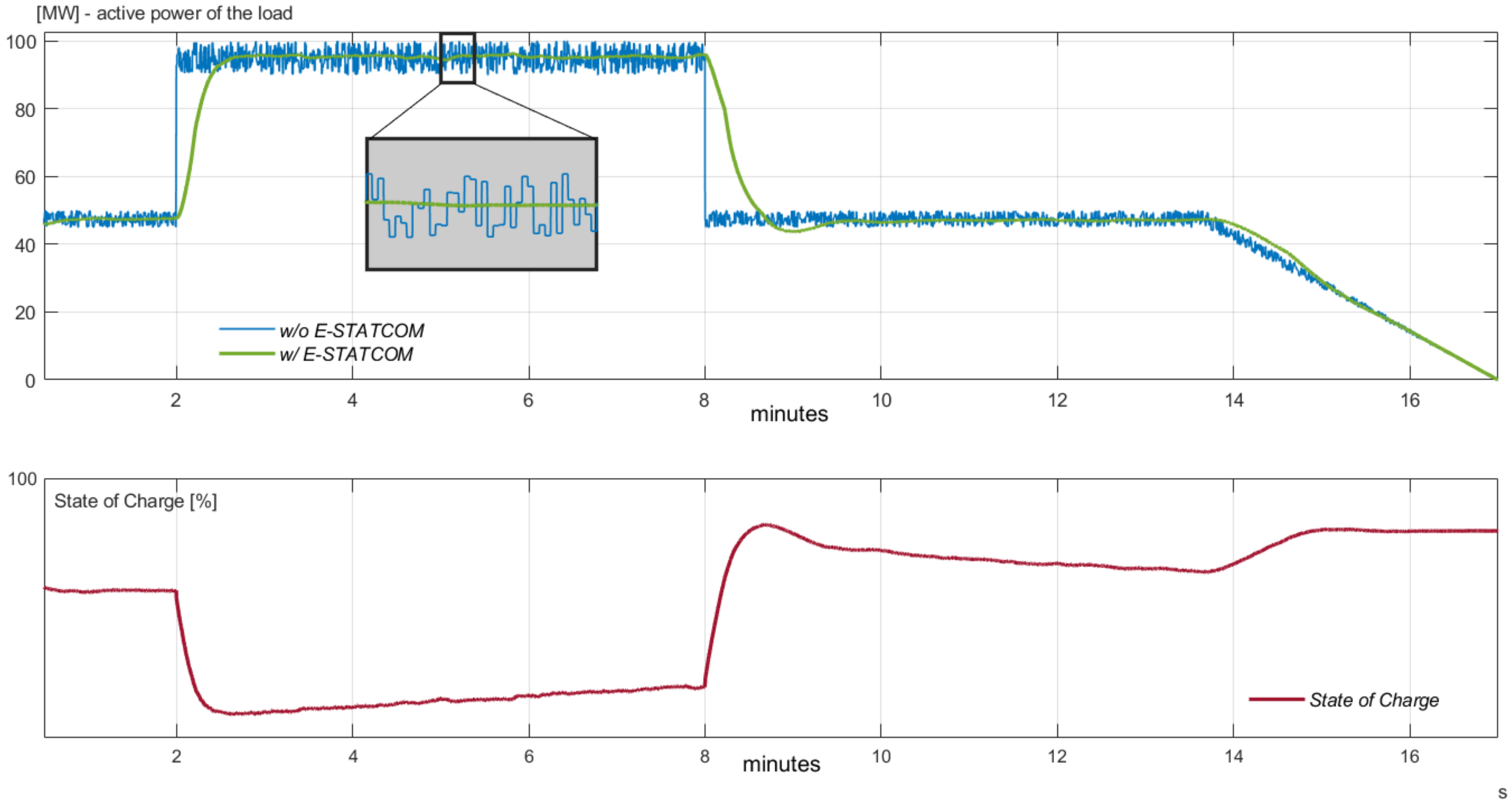




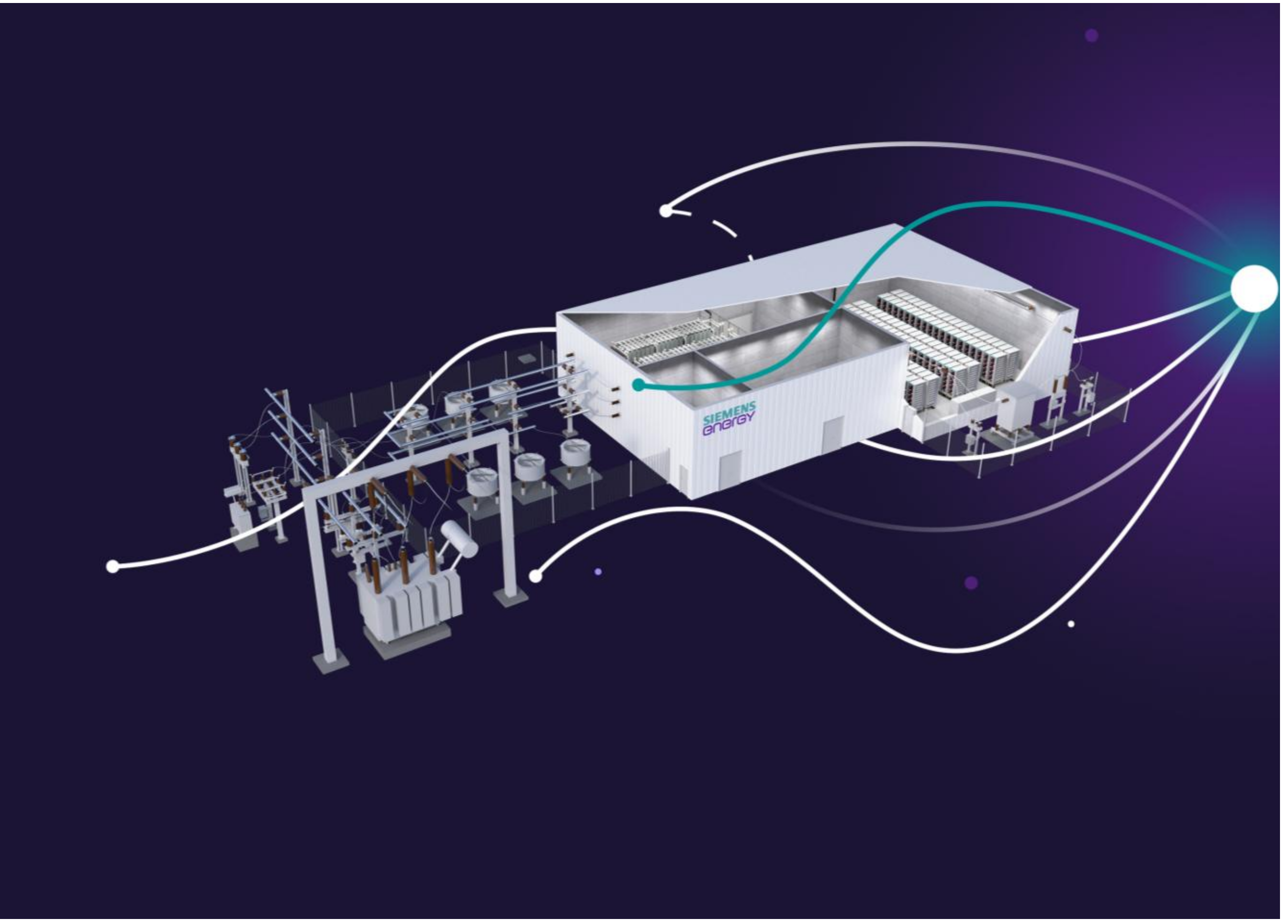
An approximation inspired by the load pattern in : [NERC White Paper: Characteristics and Risks of Emerging Large Loads]

Zoom out: Minutes timescale





Contact information



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