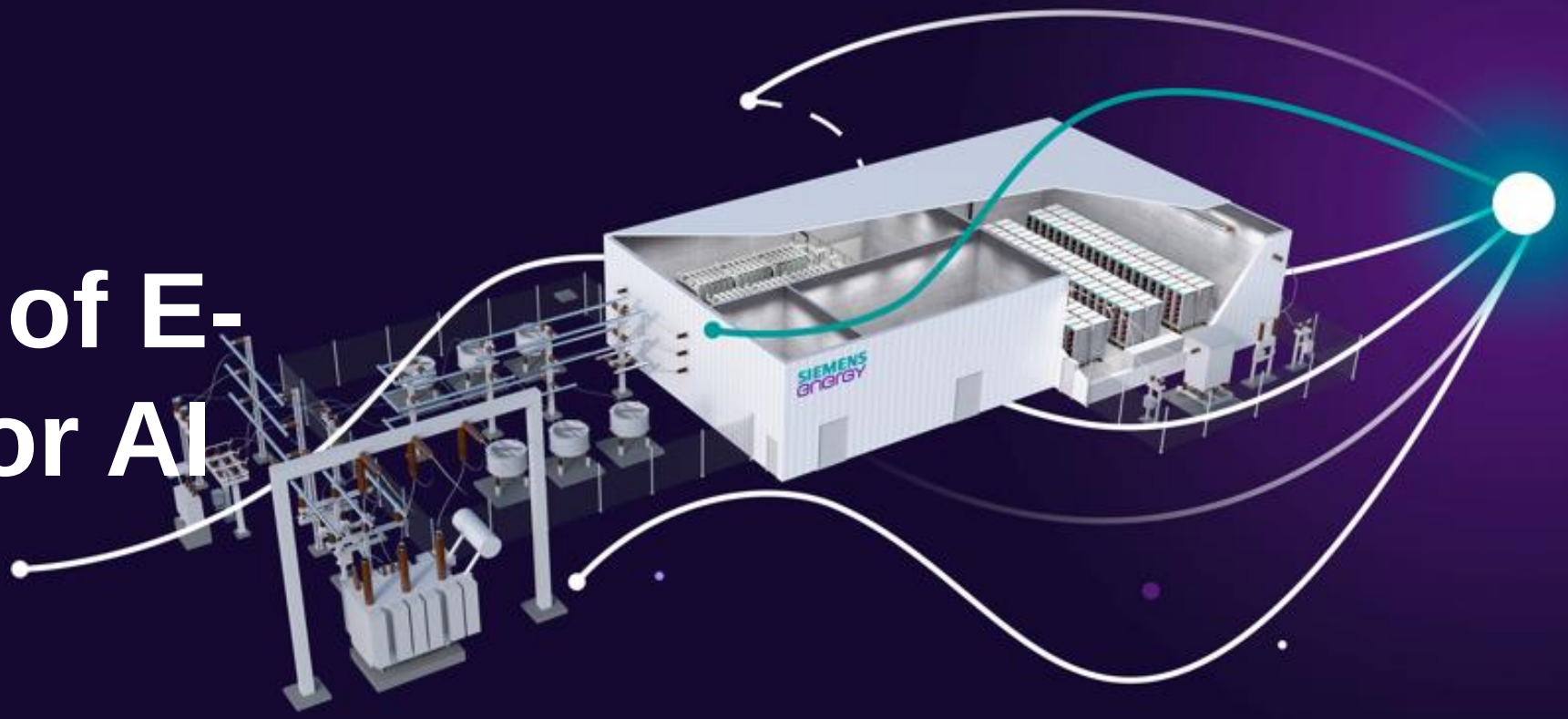
Application of E-STATCOM for AI datacenters



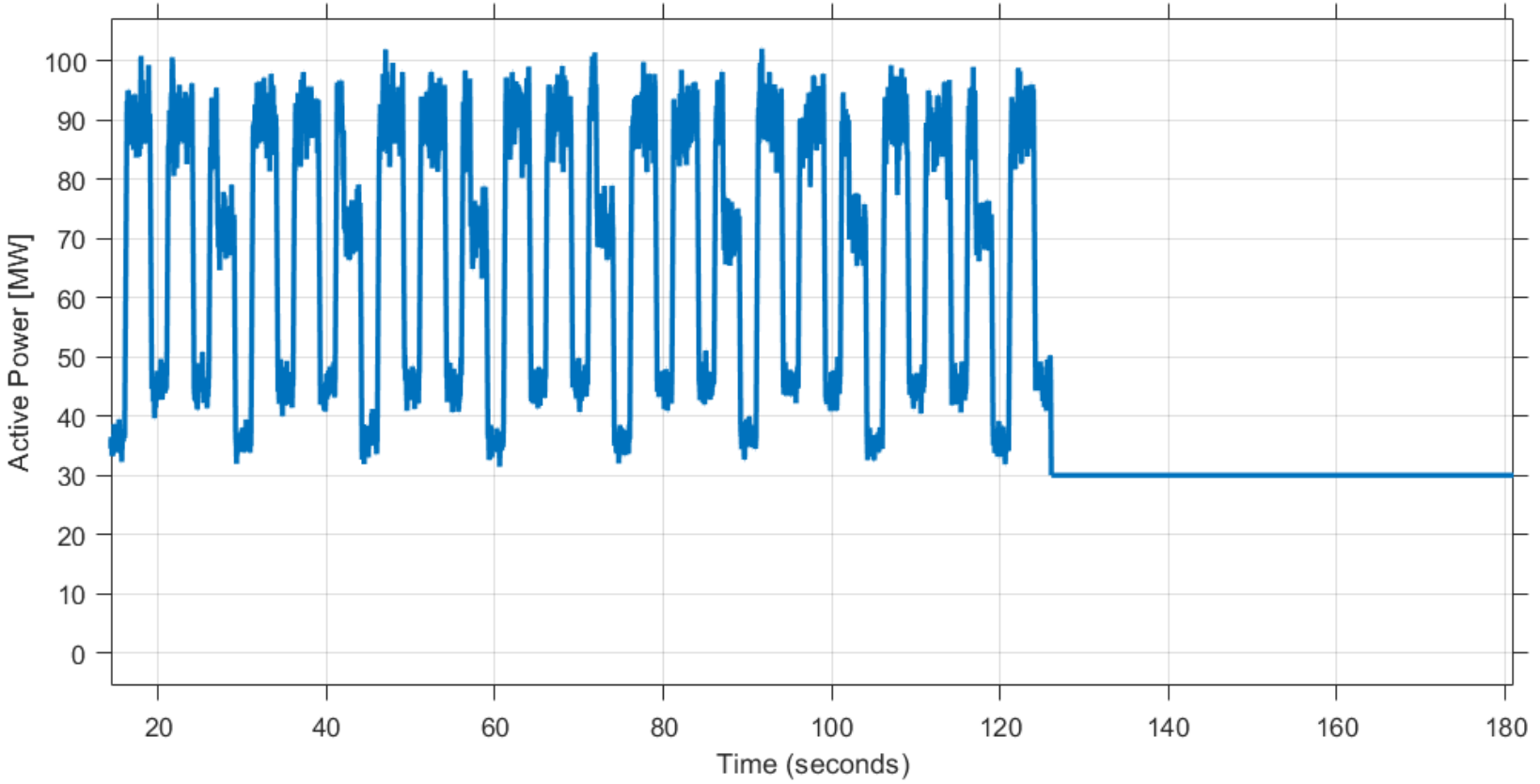
SVC PLUS FS ® www.siemens-energy.com

AI-training datacenter load pattern

Periodically fluctuating load potentially peaking every few seconds with a magnitude of up to several hundred megawatts (MW)

Negative Impact on the grid:

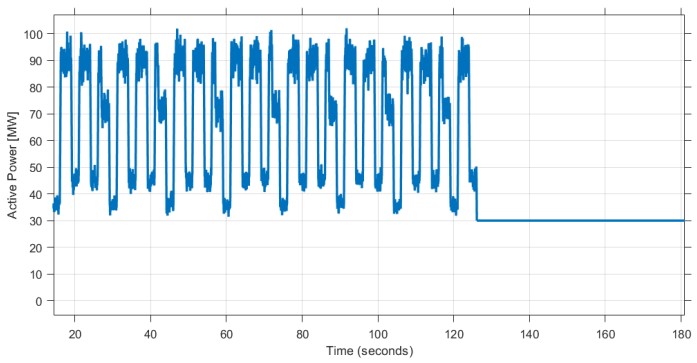
- Effects on nearby generators
- Potential for forced oscillations
- Risk of grid instability
- Voltage sags or flicker, especially in weak grids



This is a fictitious load pattern based on Pratyush Patel, Esha Choukse, Chaojie Zhang, Íñigo Goiri, Brijesh Warrier, Nithish Mahalingam, and Ricardo Bianchini. Characterizing power management opportunities for llms in the cloud. 2024.

How to define acceptance criteria?

Which specific aspects of this pattern are not well tolerated by the grid?



There are existing standards for voltage (flicker, RVC) and power quality (harmonics, NPS, etc.). However, there are no known standards to limit the load pattern.

To minimize the risk to the power grid, it is proposed to limit the load pattern based on:

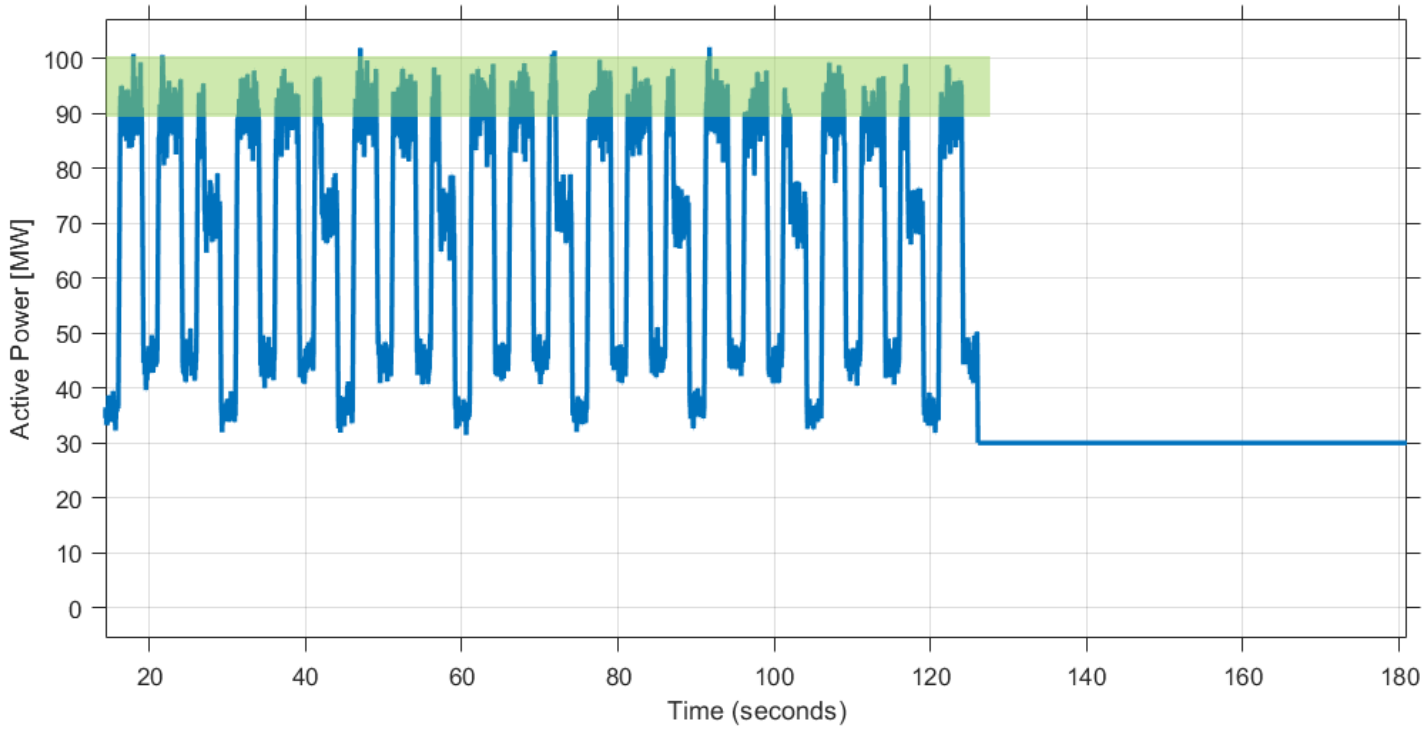
1. **Amplitude of the change**
2. **Ramp-up and ramp-down rate (dP/dt)**

How to define acceptance criteria?

Amplitude Matters:
- The grid should be able to tolerate certain levels of load fluctuation

1. Amplitude of the change

The active power fluctuation shall remain within the specified band.
Proposed band is 10% of installed power (to be discussed)



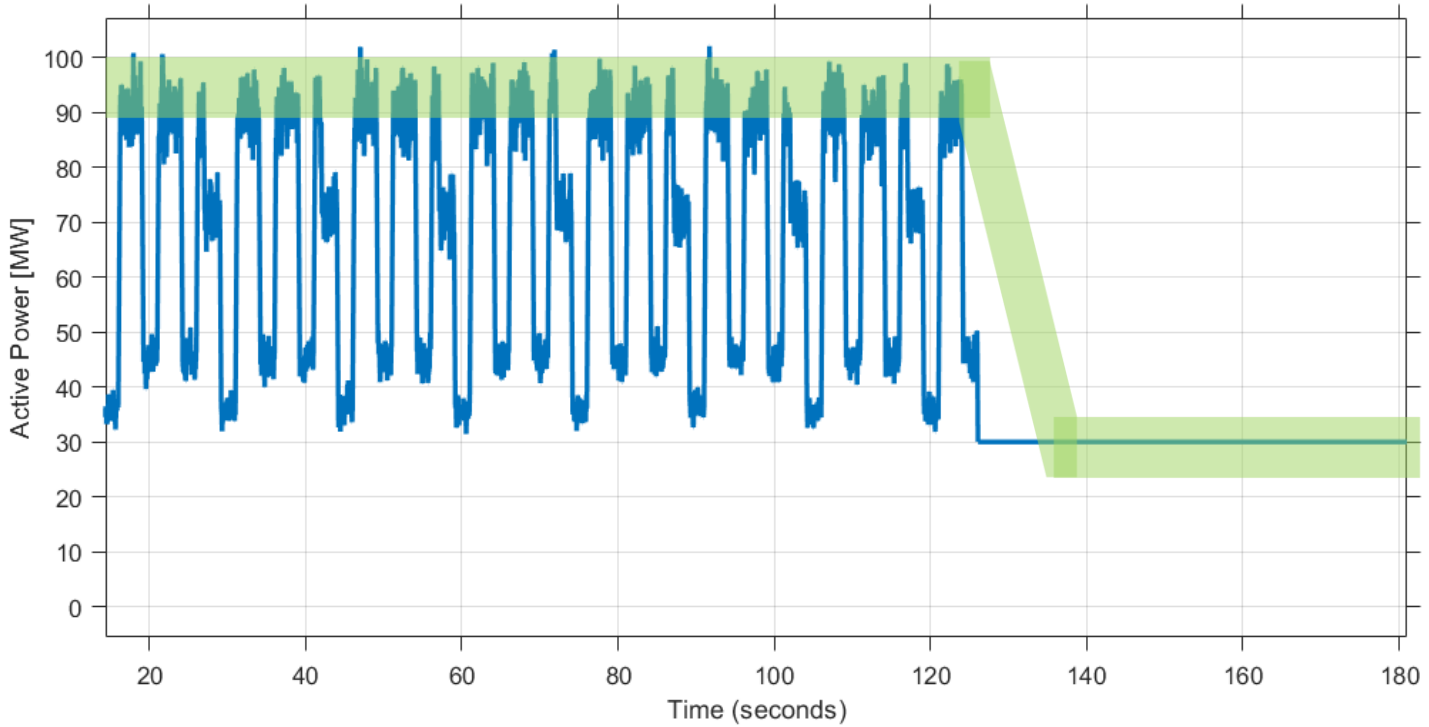
How to define acceptance criteria?

The goal is to reduce impact in sub-synchronous, local and interarea oscillations.

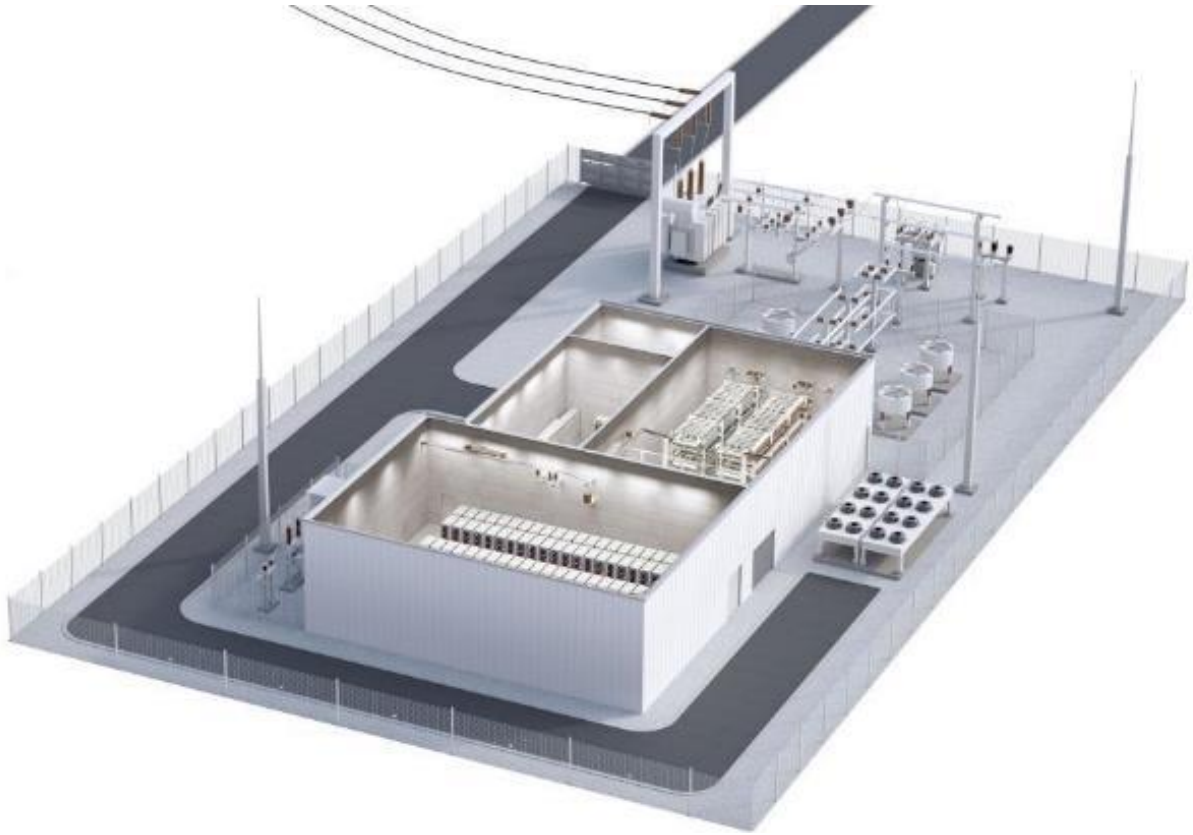
Frequencies below 0.05Hz are generally low risk. If we want to damp frequence above 0.05Hz, the ramp shall be limited to 0.314pu/s (=2*π*0.05Hz)

2. Ramp-up or -down rate (dP/dt)

If the active power deviates beyond specified band, the rate of change shall not exceed specified dP/dt rate. Proposed rate is 0.314pu/s of installed power (to be discussed)



E-STATCOM provides energy buffer



Product	**SVC PLUS FS (Siemens Energy)**
Active power	**+/-75MW**
Reactive Power	**+/-75MVAR**
System Voltage	**34.5kV – 500kV (use its own step-up Xfmr)**
Special Features	**- Variable Load Compensation - Fault-ride through support - Reactive Power Compensation - Voltage control**

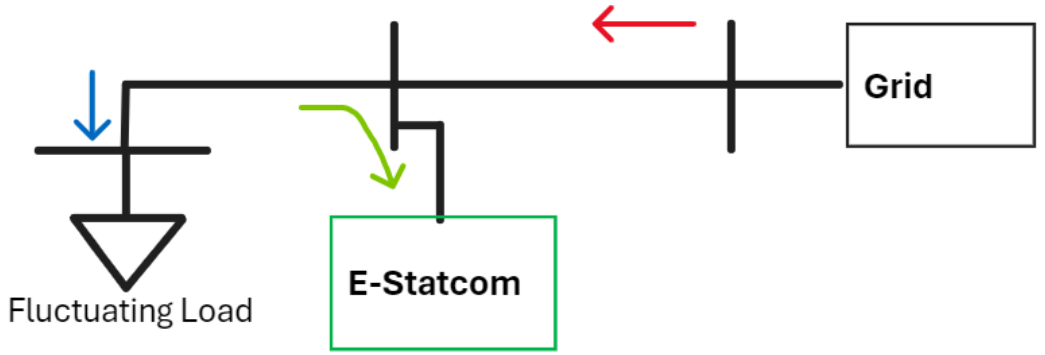
Control strategy selection

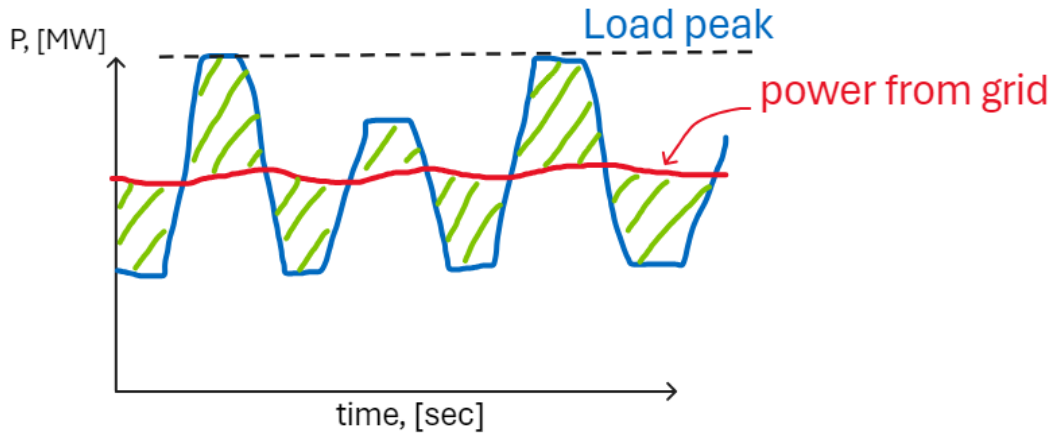
Grid-Forming Control is Not Effective for This Task:

Both GFM device and the grid act as slack buses. For the GFM device to have a noticeable impact on the load, it would need to be larger than the grid.

Open-Loop Control is the Best Choice:

•Simple and robust control, similar to that used in arc-furnace applications
•Effectively absorbs fluctuating components
•Maintains grid voltage

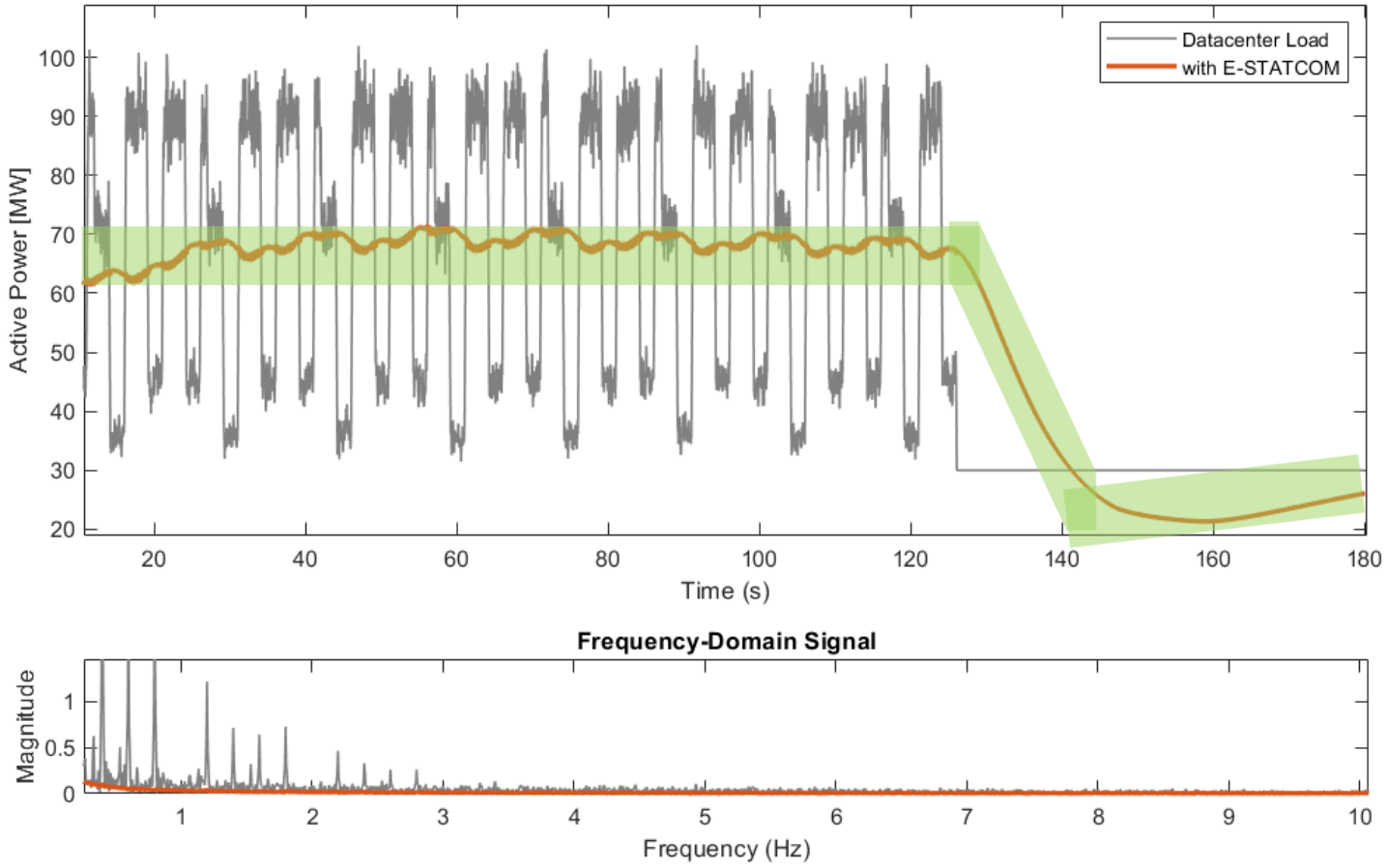




E-STATCOM provides energy buffer

The E-STATCOM is sized and tuned to fulfill the specified performance requirements:

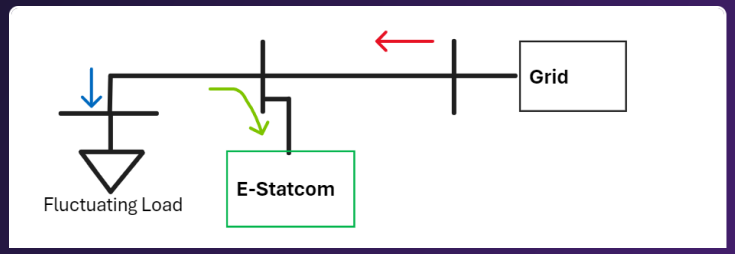
- *The active power shall remain within a fluctuation band of 0.1 pu. If the active power deviates beyond this band, the rate of change shall not exceed 0.314 pu/s. All per-unit (pu) values are referenced to the total installed power of the load.*

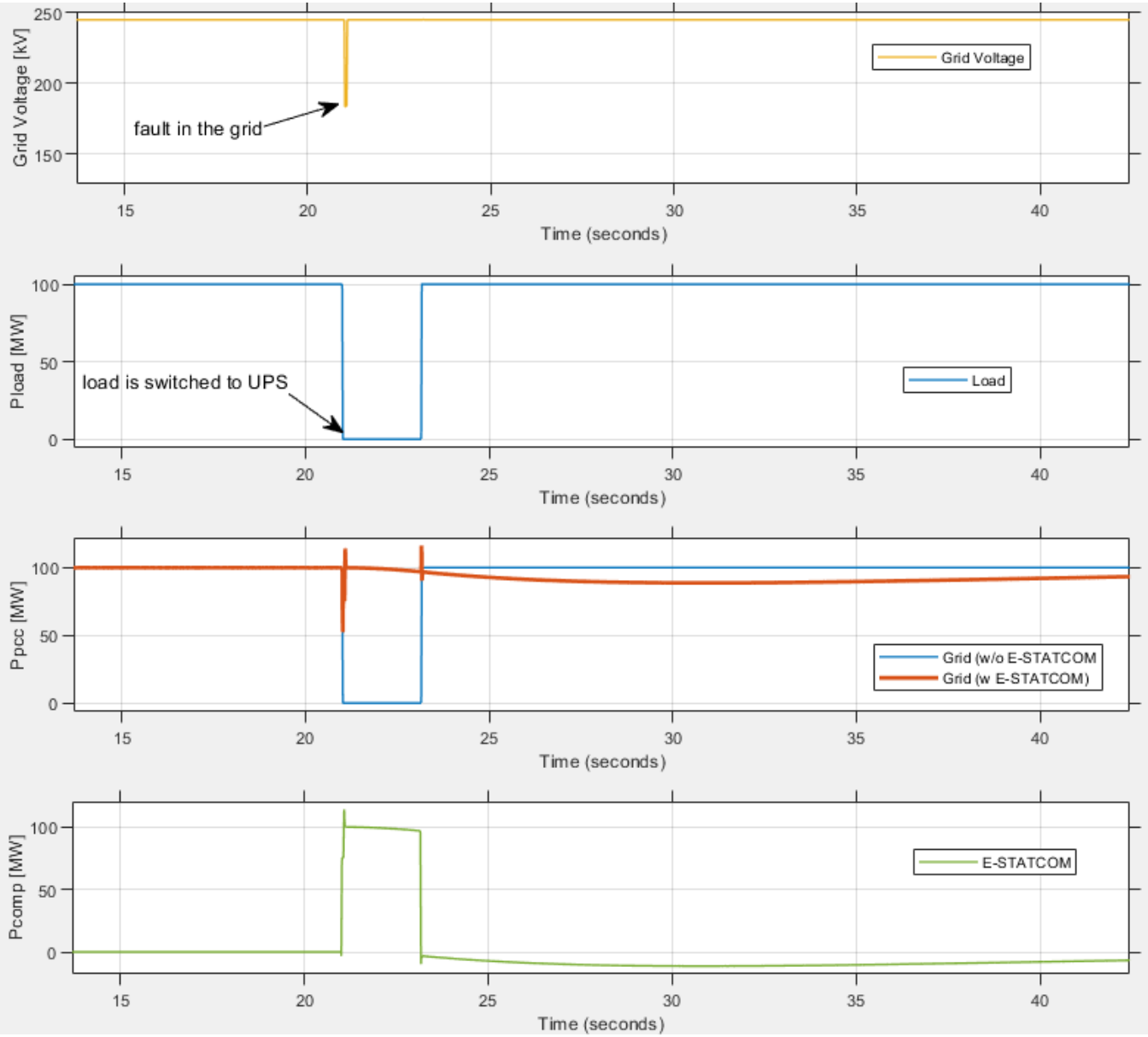


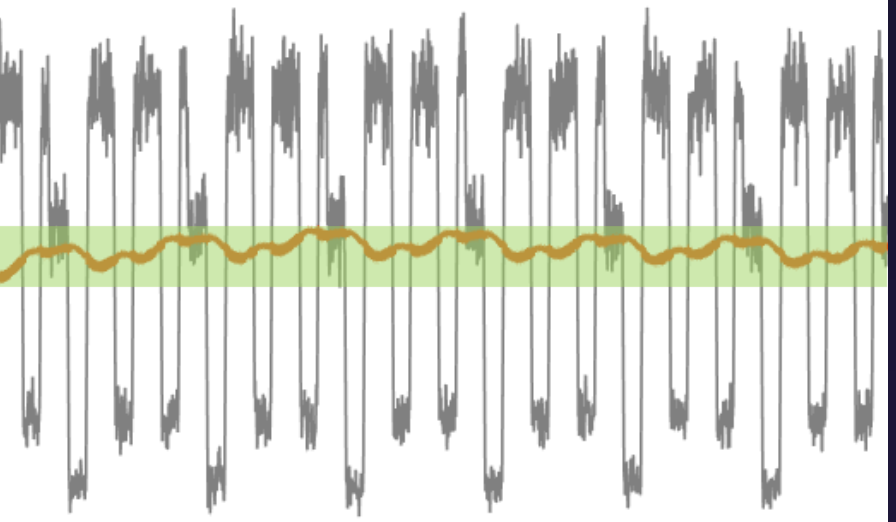
Load switches over to UPS

E-STATCOM:

- injects reactive power during faults
- bridges the active power gap while load is switched to UPS



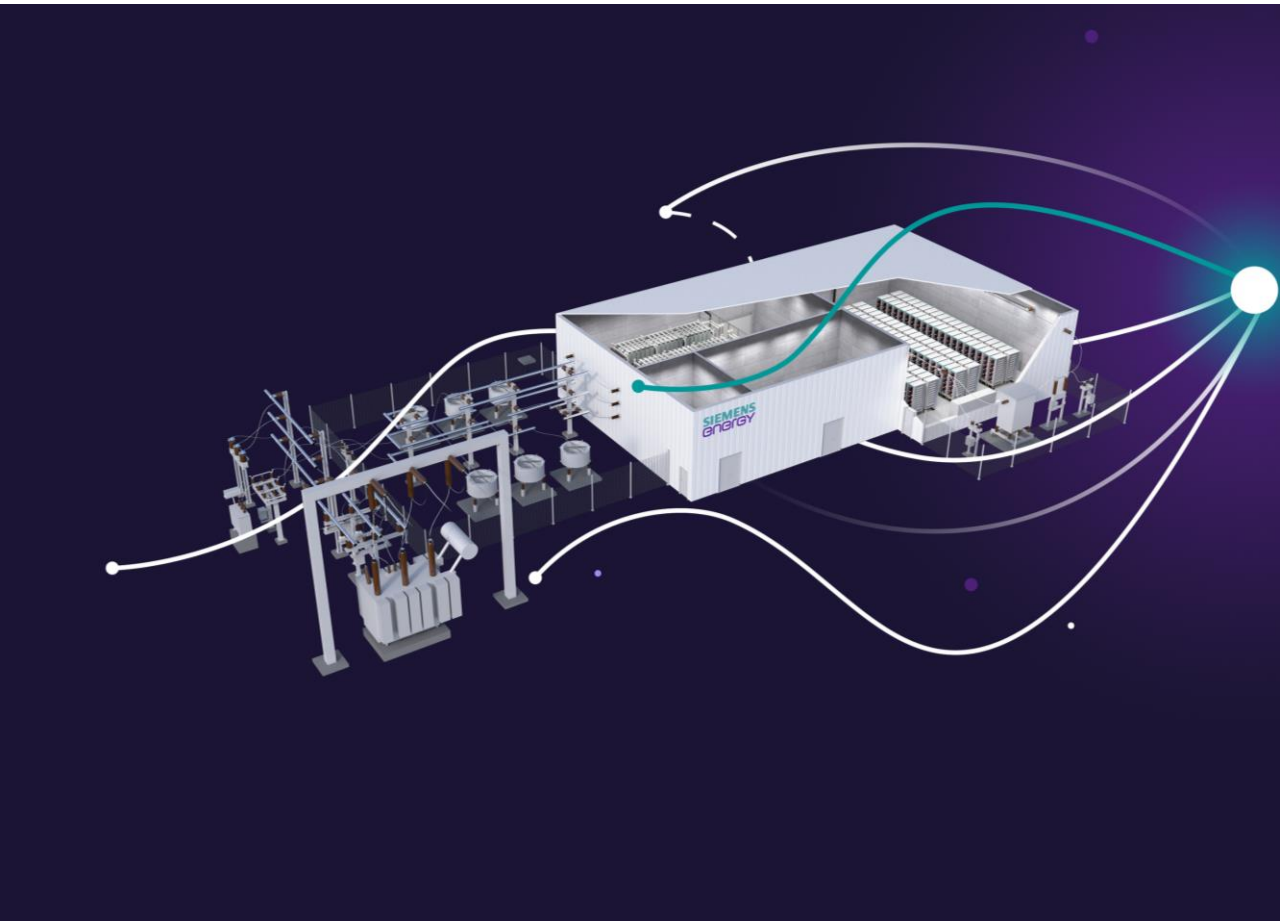




Conclusion and discussion

- AI datacenters have unique load characteristics that are new to the power grid.
- Without clear performance requirements, there is little incentive to invest into any solution.
- The lack of defined performance requirements makes it challenging to design the appropriate solutions.
- Performance criteria should balance economic impact with the needs of the grid.

Contact information



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