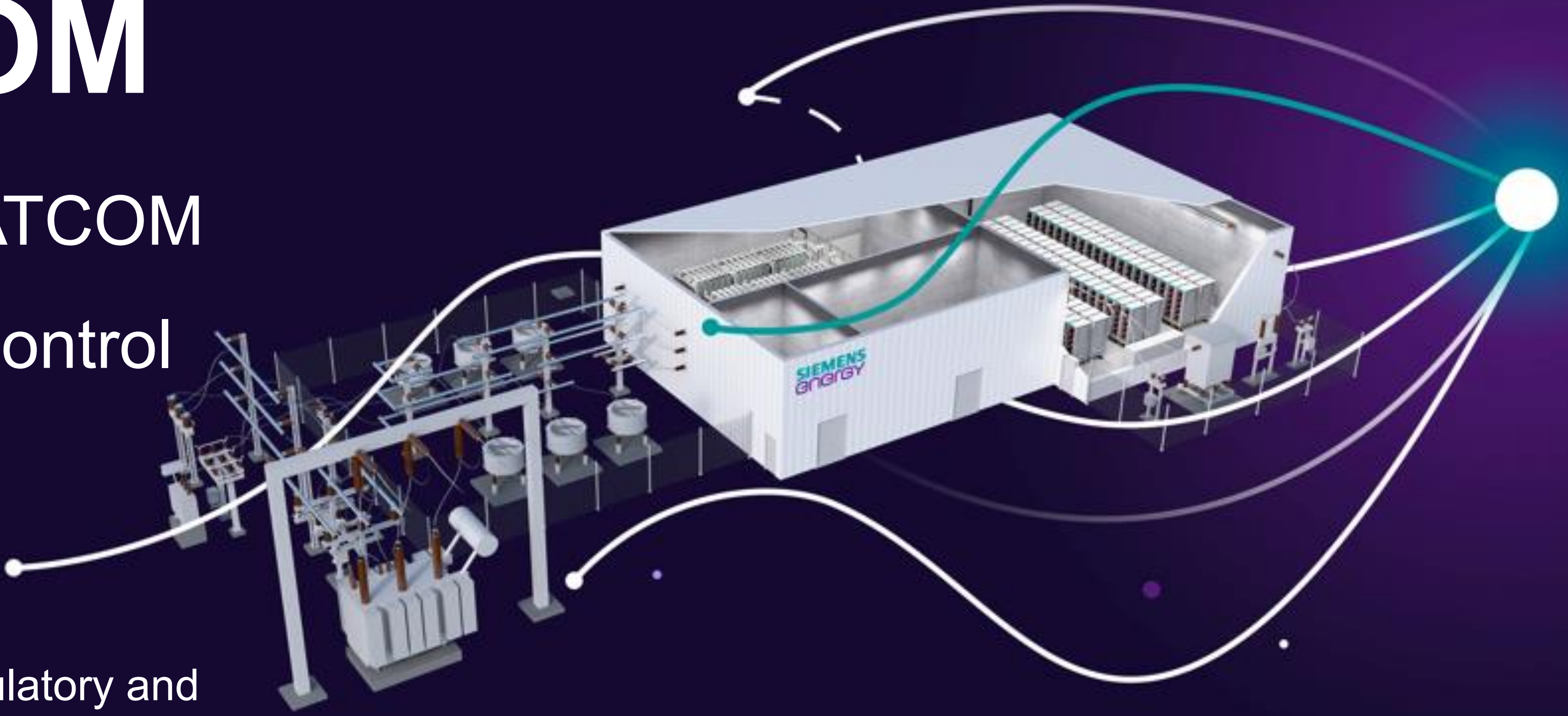
E-STATCOM

2nd Generation STATCOM

with Grid-Forming Control



Technical Challenges and Regulatory and Policy Solutions, Berlin 06 Oct 2025

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E-STATCOM: Network component stabilizing voltage and frequency in the transient time domain

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Power Transformer

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Multilevel Voltage Sourced Converter

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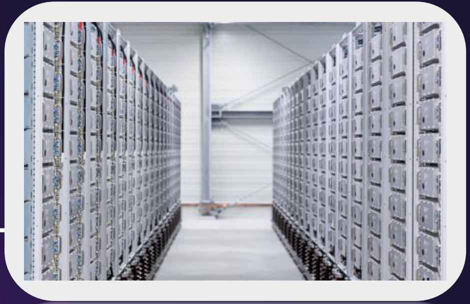
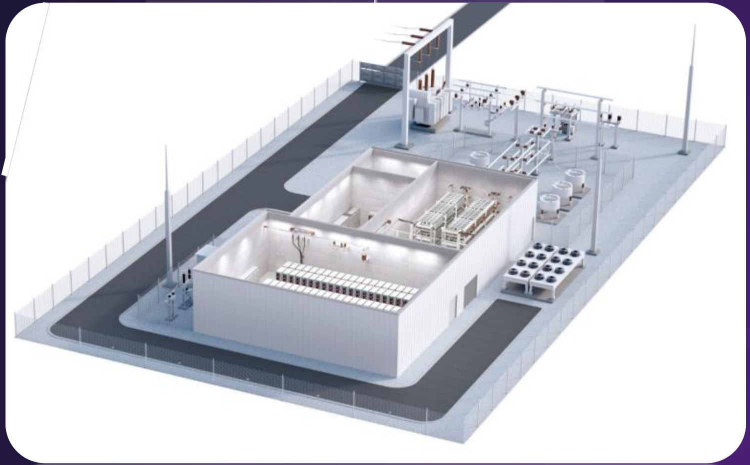
Super-Capacitor Unit





- Voltage control in magnitude and phase-angle.
- Simultaneous injection of active and reactive currents
- Programmable controller w. grid-forming control

- Short-term energy reserve
- Emulated inertia provision
- Islanded operation

- Low losses
- Long lifetime > 20a
- High availability

4 German TSO's specified unified ratings for the installation of future "STATCOM 2nd Generation" in the German 400kV grid

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E-STATCOM Rating

S_n = 300 MVA

Q_n = 300 Mvar

P_{max}= 150 MW

Emulated Inertia – default:

E_{kin} = 1.875 MWs

+/- P_{max} @ RoCoF +/- 2 Hz/s

+/- ½ P_{max} @ RoCoF +/- 1 Hz/s

T_a = 12.5 s rel. to S_n , 25 s rel. to P_{max} acceleration constant

Features:

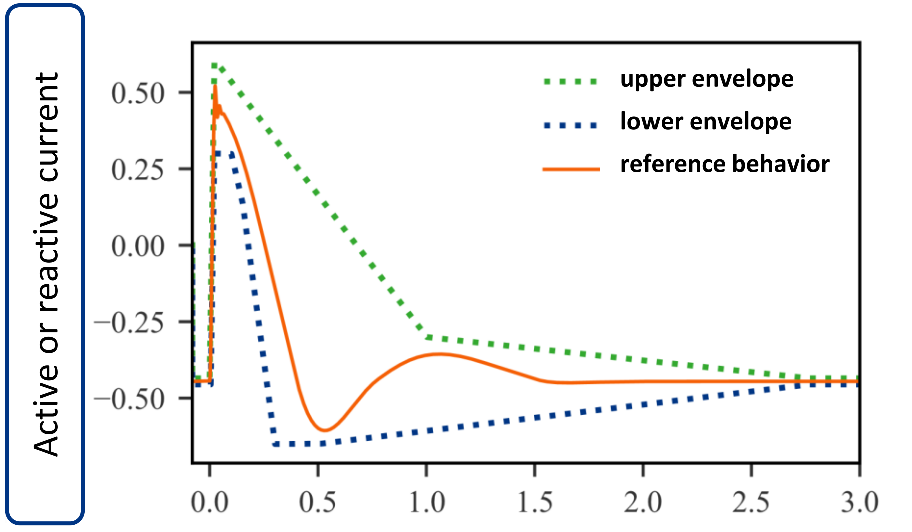
- ➢ Instantaneous response at voltage magnitude and phase jump
- ➢ Inertial response at frequency gradients
- ➢ Damping of oscillations in wide frequency range (sub-synch, harmonics)
- ➢ Voltage support during and after fault
- ➢ Operation in weak grid condition
- ➢ No frequency regulation (FFR, PFR, SFR…)

Parameterization:

- ➢ T_a tuning (*) to more inertia contribution at small signal frequency excursions → limitation of response when design limits P_{max} are reached.
- ➢ Different response in positive and negative direction possible.

e.g. T_a = 40s → Ekin = 6000 MWs.

Grid-Forming Control: Performance verification through reference curves w. envelops defining the limits of response



- Defined test environment
- Measurement specification
- Reference behavior / envelopes as an acceptance criterion
- Additional functional requirements, e.g. no oscillations

- Violation of reference curves / envelops:
  - Adjustments of control
  - Discussion and mutual agreement between TSO - OEM

Slide released from TenneT (G. Deiml) on Sept 8th 2025. Modified & translated by Siemens Energy (G. Kuhn)

STATCOMs are networkk components and offered EPC turnkey. Design varies according to project specific requirements.

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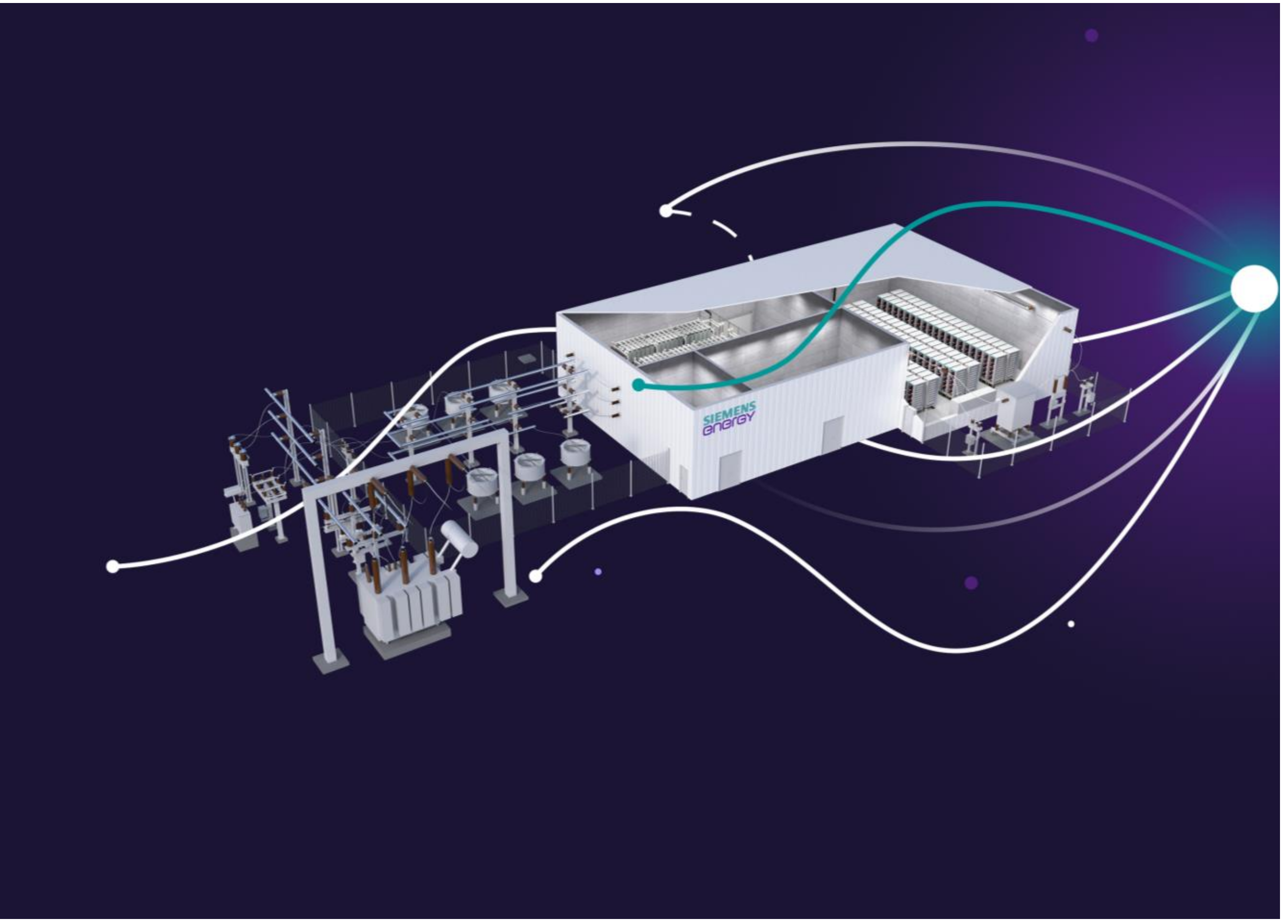
- ➢ STATCOM design is influenced by project and site specific requirements.
- ➢ Long lasting process of performance validation of GFM-control.
- ➢ Flexibility in design → long project lead time.

Unified system & station design and project bundling increase overall efficiency.

- ☝ Grid-Forming Control should not influence system design data.
- ☝ „Over-tuning“ of GFM-control (e.g. inertia, virtual admittance) may impact lifetime or exceed design limits.
- ✖ GFM-Control is expected to be state-of-the-art. Request for switching GFL - GFM control creates unnecessary effort.
- ✖ Performance verification of GFM-control through EMT-simulations. Limited options for tests late in project and on-site.
- ✖ Additional generic stability functions (*) increase complexity. Specific functions and performance requirements need to be specified in detail.

(*) e.g. POD, SSR, active damping

Contact information



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Siemens Energy, Grid Technologies,
Grid Solutions, FACTS
Lead Engineering

German Kuhn
Siemenspromenade 11
91058 Erlangen

E-mail: german.kuhn@siemens-energy.com

www.siemens-energy.com