Grid forming control

A 50Hertz view on requirements for HVDC & STATCOM

03/22/2022 | Cornelius Heck

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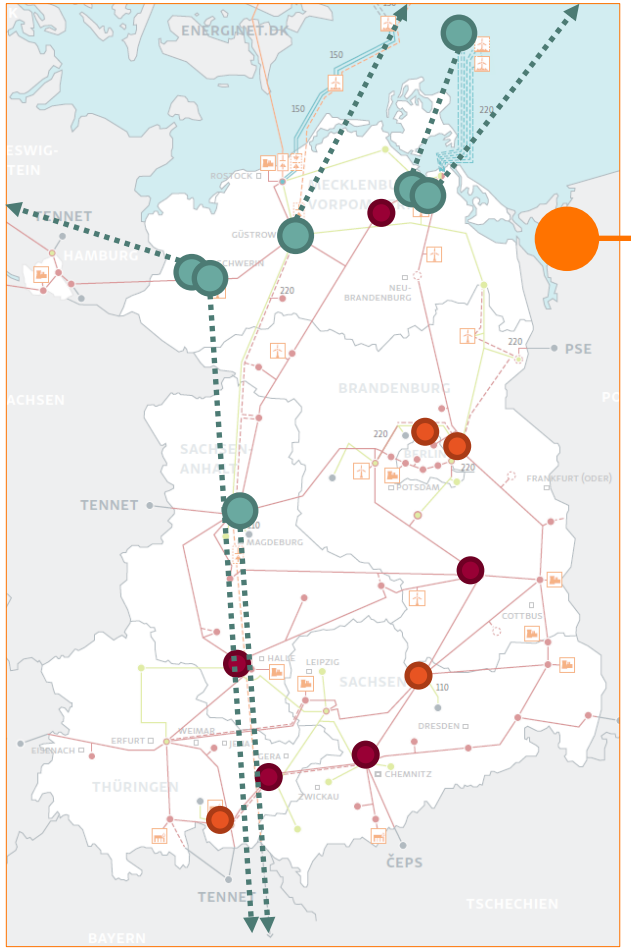
A 50Hertz view on requirements for HVDC & STATCOM

Agenda

- Motivation
- Our Grid Forming understanding
- German VDE FNN Guideline on grid forming behavior of HVDC
- Outlook

50Hertz – power electronics at a glance



High share of RES

2020	**2032**
57 GW	104 GW

Loss of ancillary service sources due to coal phase out

Increasing costs for stability related redispatch

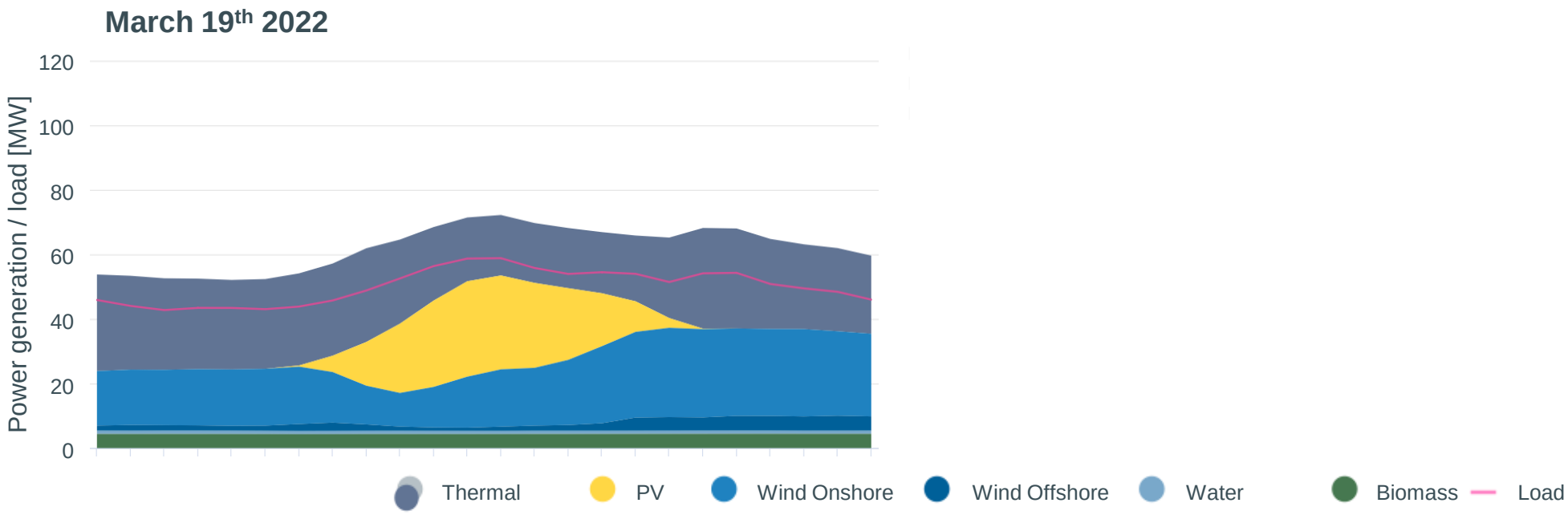
Extension plan until 2030
- 10 GVA of HVDC converters
- >4 GVA of STATCOM

SCR < 1,5 in normal conditions

"From 60 to 100 until 2032"

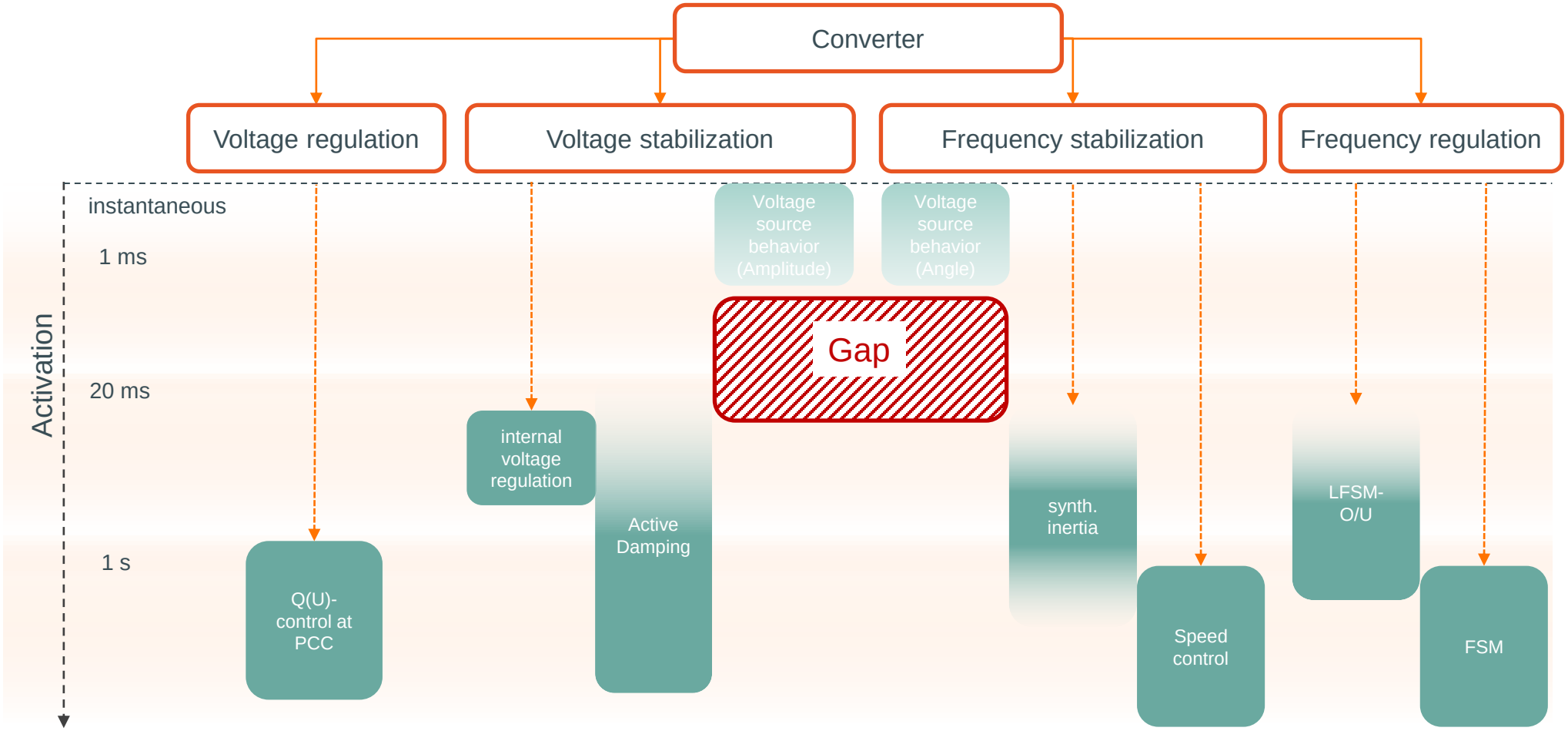
Motivation

Power generation and demand in Germany



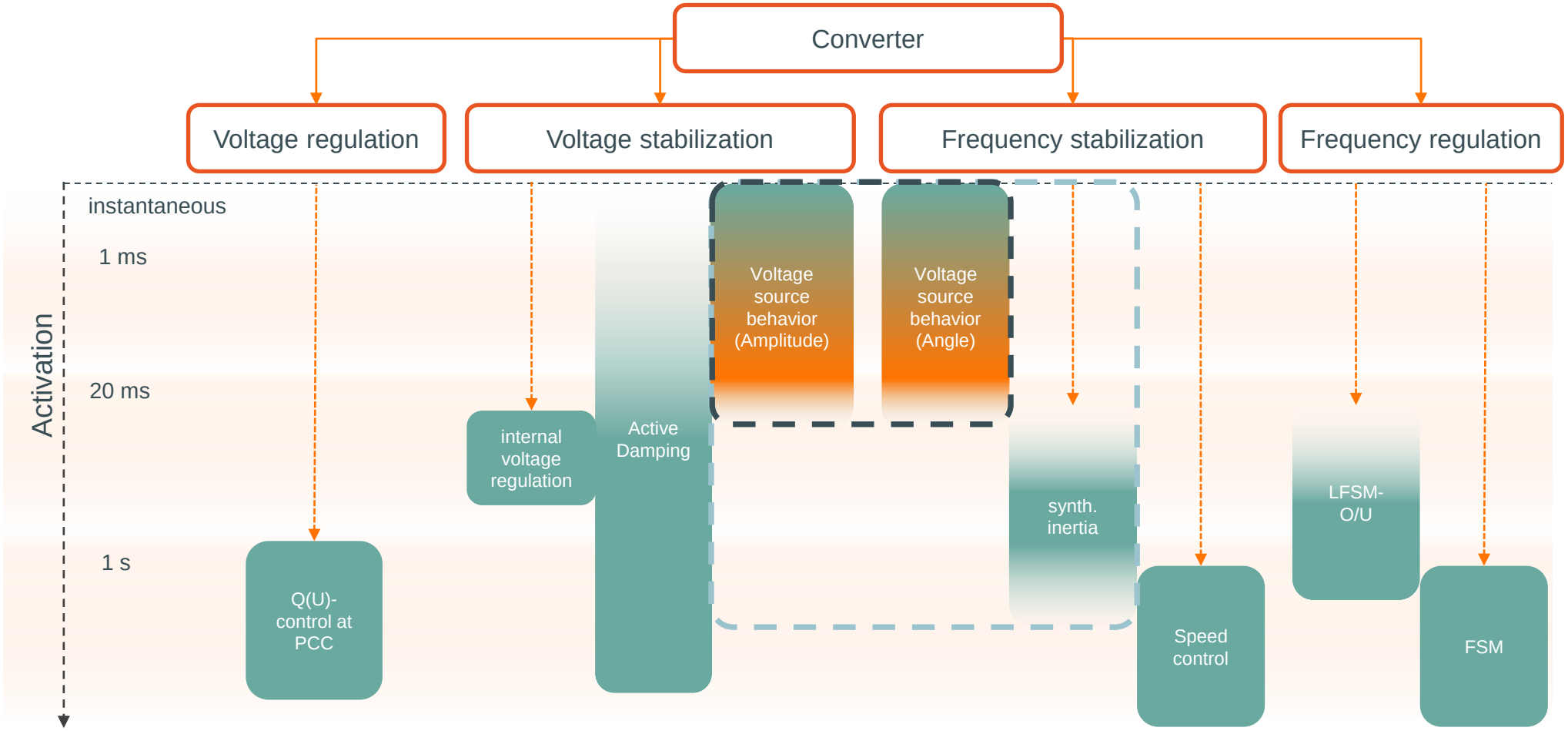
Source: Agorameter (agora-energiewende.de)

Grid following behavior



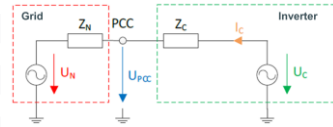
Stability issues at GFM shares > 60 %

Grid forming behavior



Capability also in GFM

Voltage source behind impedance



Inertia analog to synchronous machine

From general understanding to practical assessment

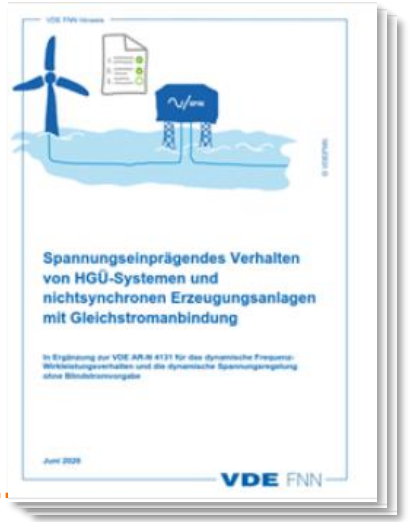
entso-e HPoPEIPS

- Allow AC grid operation without SG
- Creating system voltage
- Contributing to fault level
- Sink for harmonics
- Sink for unbalance
- Contribution to inertia
- Preventing adverse control interactions

?

VDE FNN Guideline

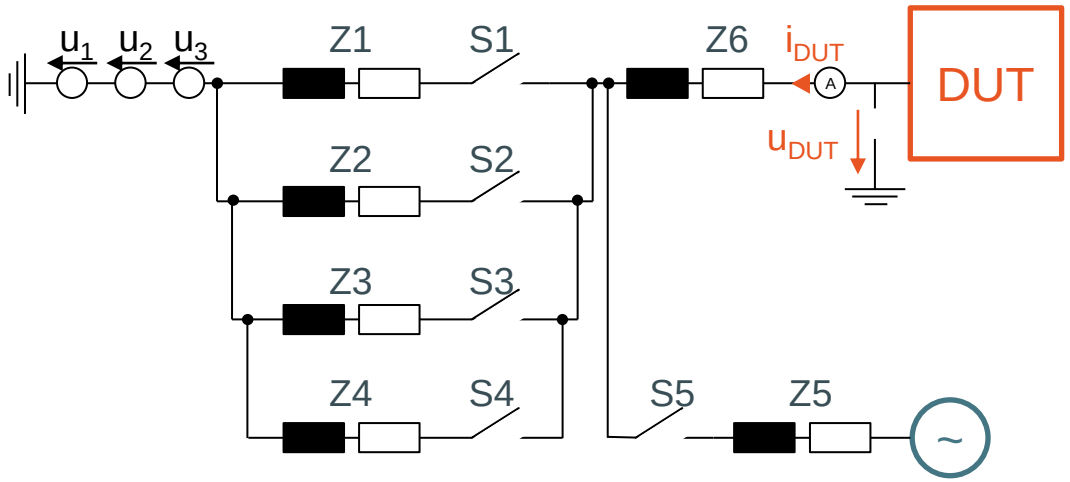
Provide a framework for implementation in terms of specifications and conformity methods.



Goal: Assess desired behavior without dictating control.

Grid forming behavior of HVDC systems and DC-connected PPMs

Test cases and network



VSC controlled as current source with internal impedance

Equivalent circuit of the test network for DC-connected PPMs
Source: [FNN Guideline: Grid forming behaviour of HVDC systems and DC-connected PPMs, 2020]

Test cases

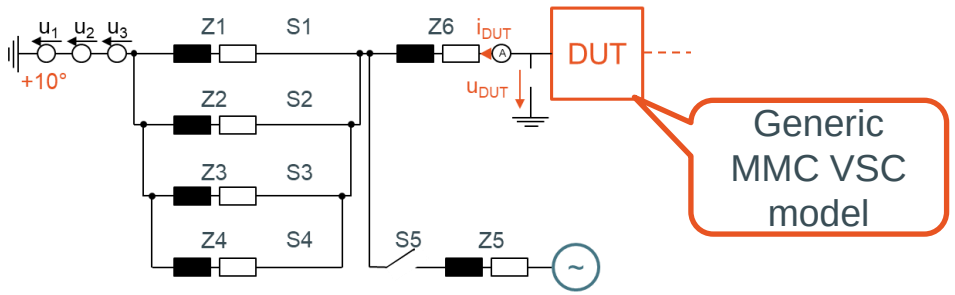
1. Phase angle step of network voltage
2. Linear frequency change in network voltage with initial phase angle step
3. Voltage magnitude step in network voltage
4. Presence of a negative-sequence component in the grid
5. Presence of harmonics
6. Presence of subharmonics
7. Change in the network impedance
8. Islanding with voltage source under grid forming control

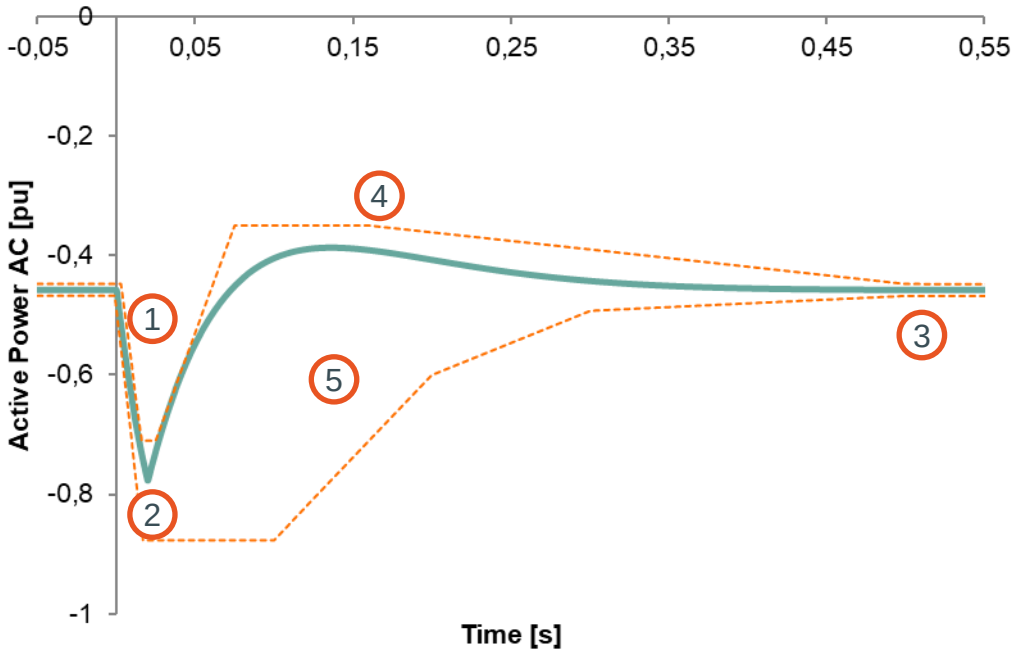
Grid forming behavior of HVDC systems and DC-connected PPMs

Example HVDC with 10° phase jump

What we want to see …

1. Inherent reaction
2. Maximum reaction after max 30 ms
3. Reduction within 500 ms
4. Well damped behavior
5. Smoothed reaction on opposite station





Where to go from here?

Open questions

1. How to minimize the stress of grid forming on each end of an HVDC line?
2. How to implement converter current limits?
3. How to consider energy storage correctly?
4. How to determine systemic GFC needs?
5. What is minimal energy storage to identify as GFC?

Next steps

- Implement GFC requirements generation units Amendment of ***Requirements for Generators***
- Review manufacturer tender documents
- Observe real life behavior (> 2025)

Path is set for 100% GFC in new installations.

THANK YOU!