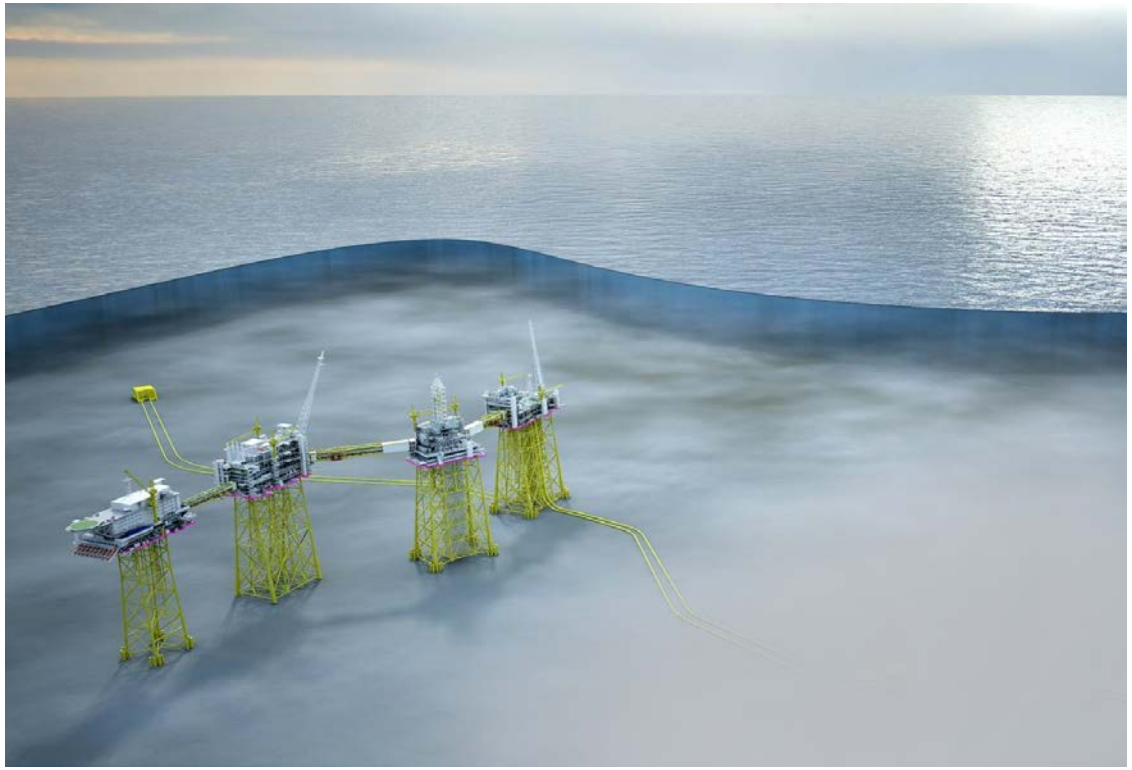


Multivendor HVDC links supplying O&G installations

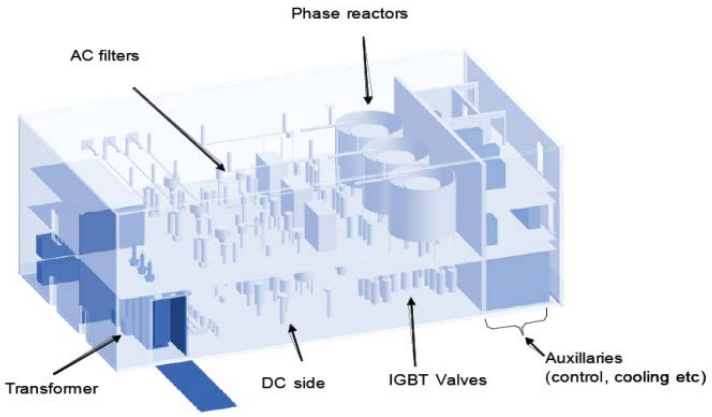
Perspectives and challenges

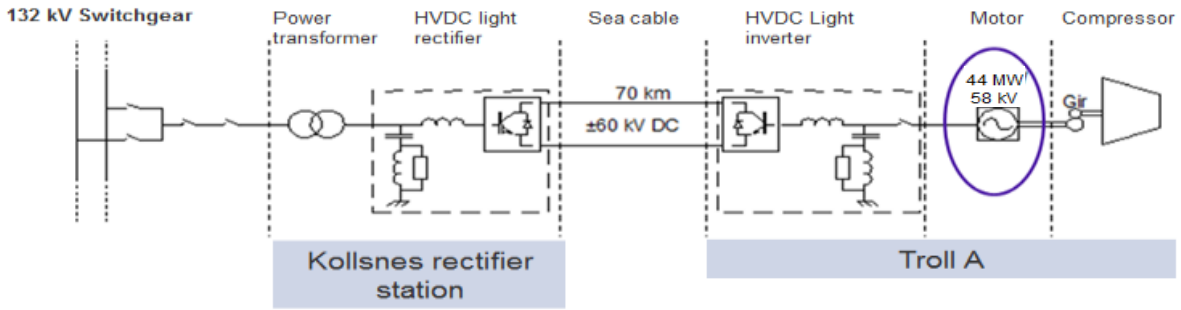
EC Workshop: Horizon 2050 power system and the role of HVDC technologies in a highly decentralised RES generation

Brussels, 4th February 2020

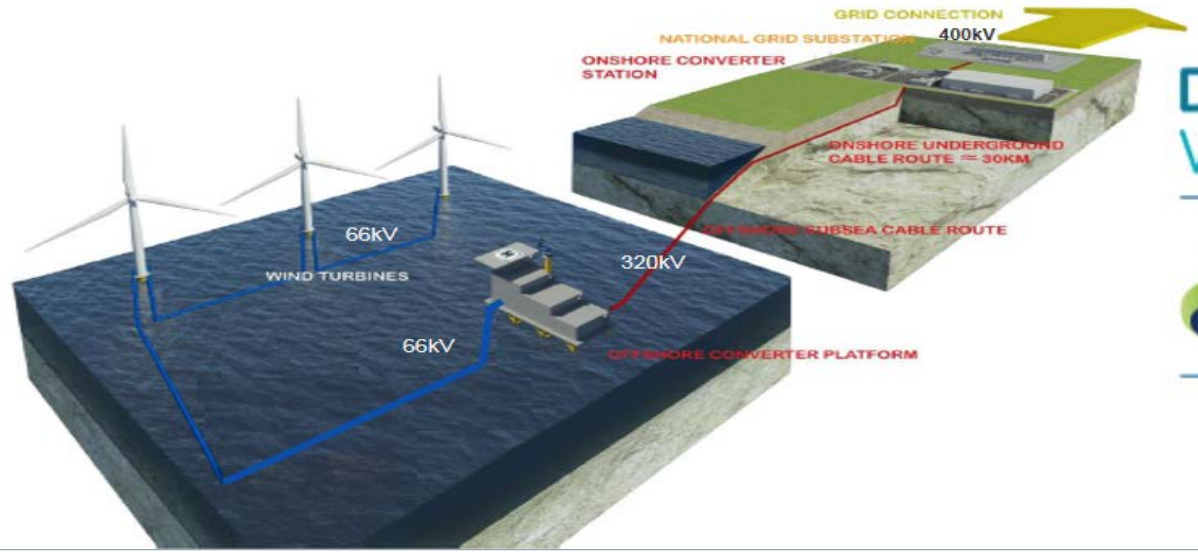
Troll A world's first offshore HVDC installation

- 2 * 45 MW, ±60kV DC, HVDC Light
- 2 * 50 MW, ±80kV DC, HVDC Light





Dogger Bank windfarm, largest European VSC -HVDC link

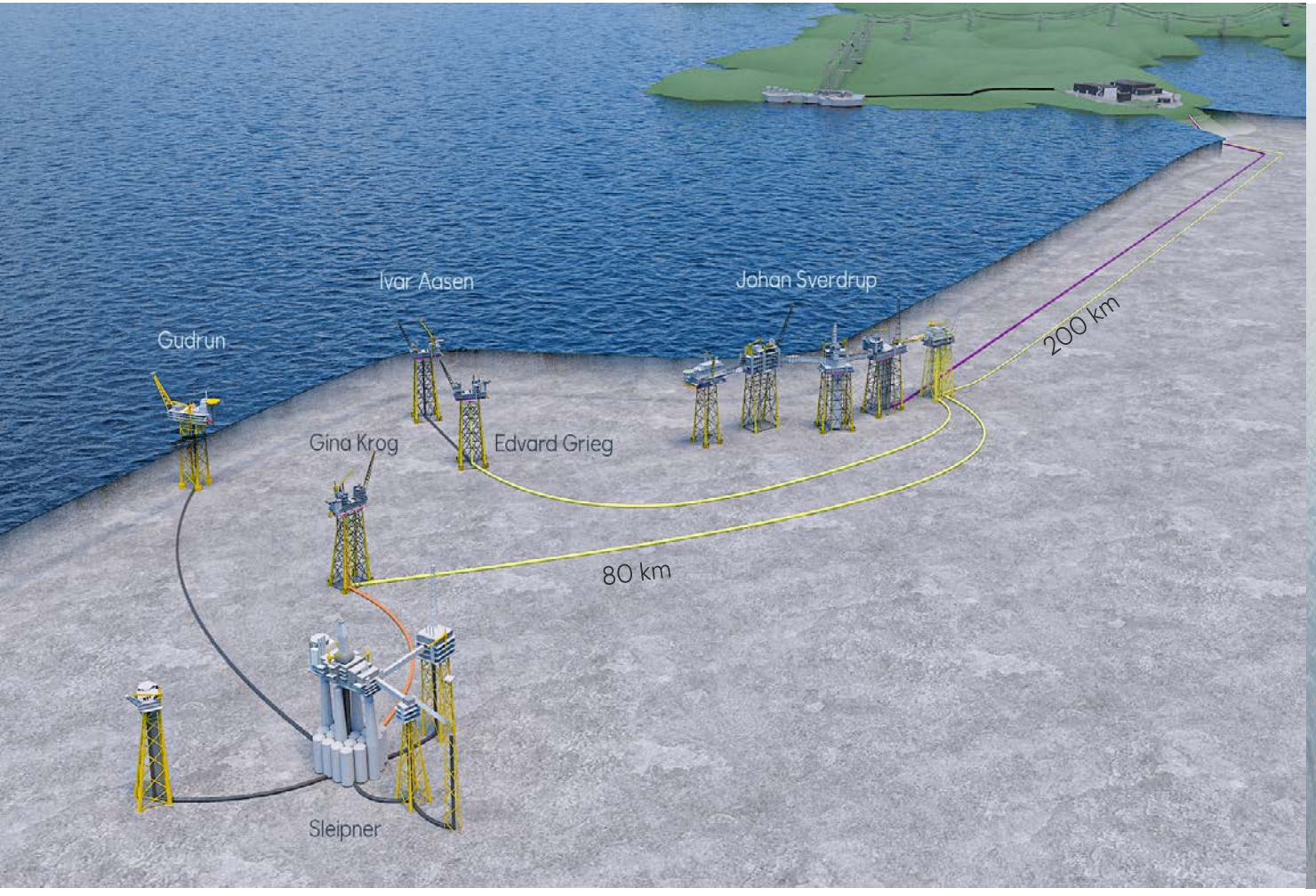


DOGGER BANK WIND FARMS
BY
sse equinor

- Park size: 3 x 1200 MW
- WTG size: 12 MW ~ 100 off per project
- HVDC export to shore
- 3 x HVDC converters

Largest North Sea AC grid, with multivendor HVDC links

(Johan Sverdrup HVDC links will supply the Utsira offshore grid)

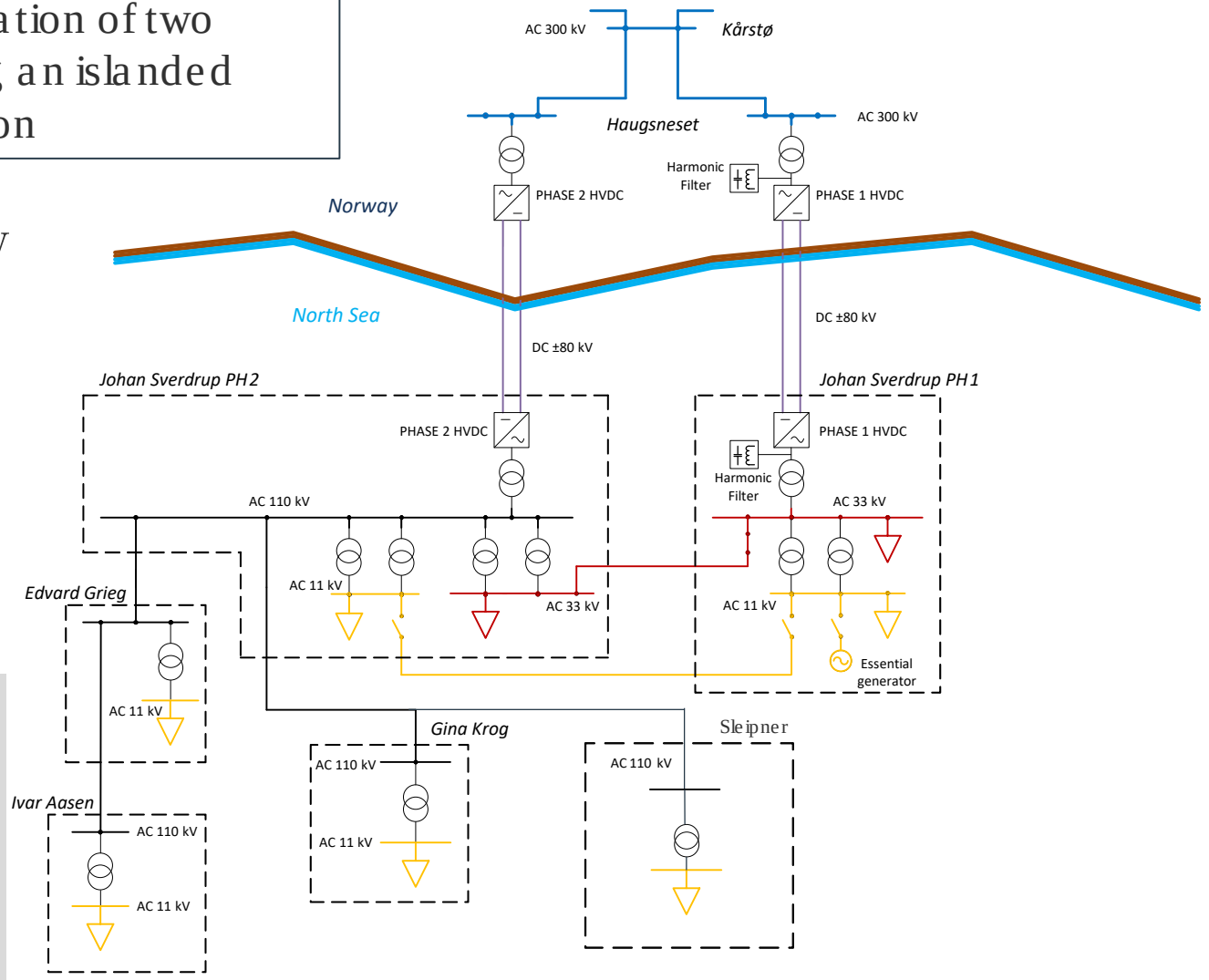


First multivendor parallel connected HVDC systems

The Johan Sverdrup project will be the first application of two HVDC links from different manufacturers supplying an islanded offshore AC power system in grid forming operation

North Sea ≈200km off the coast of Norway

- HVDC Phase 1 - 100 MW
- HVDC Phase 2 – 200 MW
- Different HVDC vendors
- Different HVDC technologies
- 110 kV subsea AC distribution network



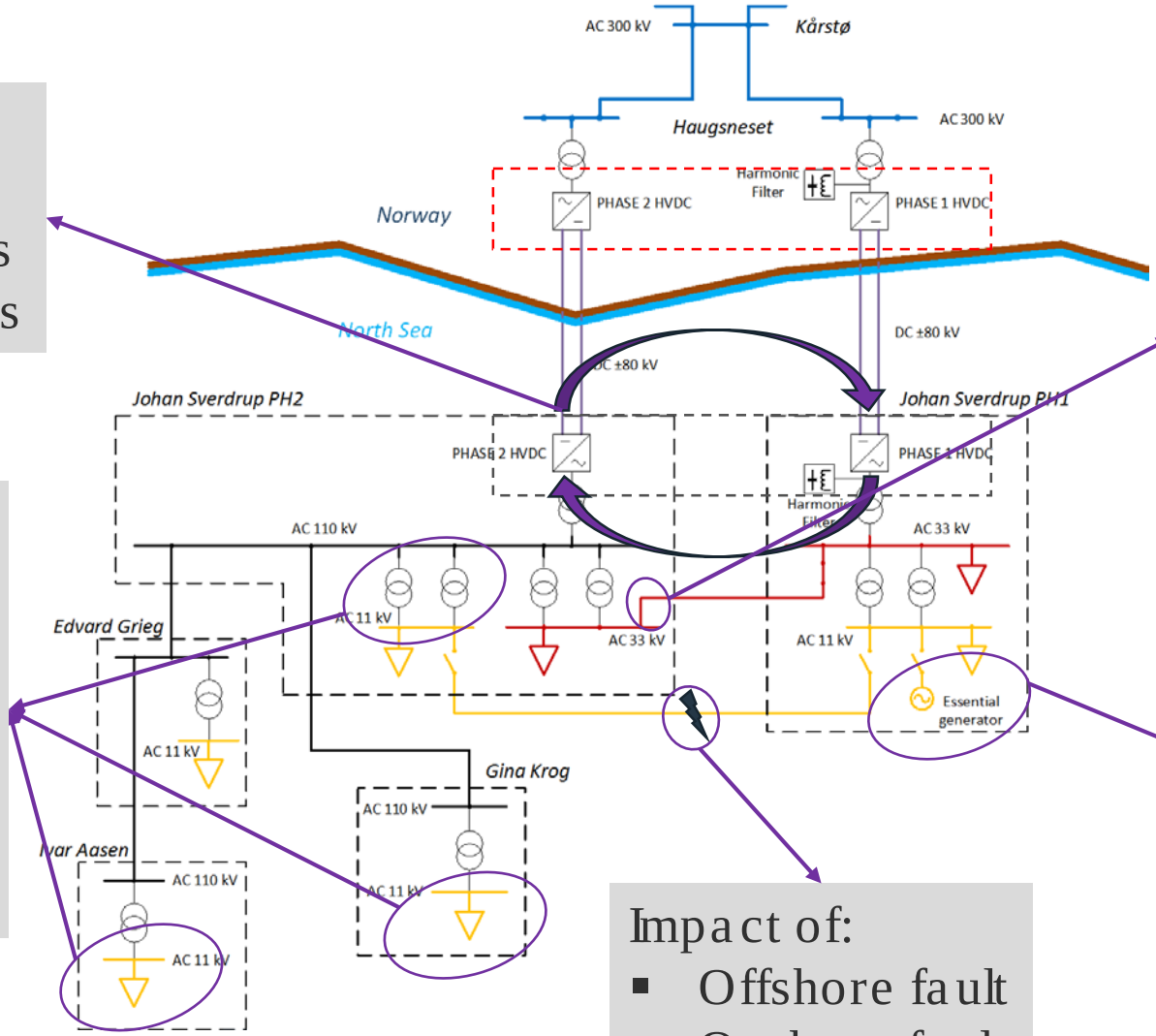
Challenges:

- *Stable operation of the interconnected power system*
- *Avoid negative interaction phenomena between the 2 HVDC systems*

Phenomena of interest with focus on interaction

Impact of:
- Converter controls
- Harmonic interactions
- Converter protections

Impact of:
- Load characteristics to voltage stability
- Energization of transformers and cables
- Load rejection



Impact of:
- Load sharing
- Synchronisation
- Decoupling

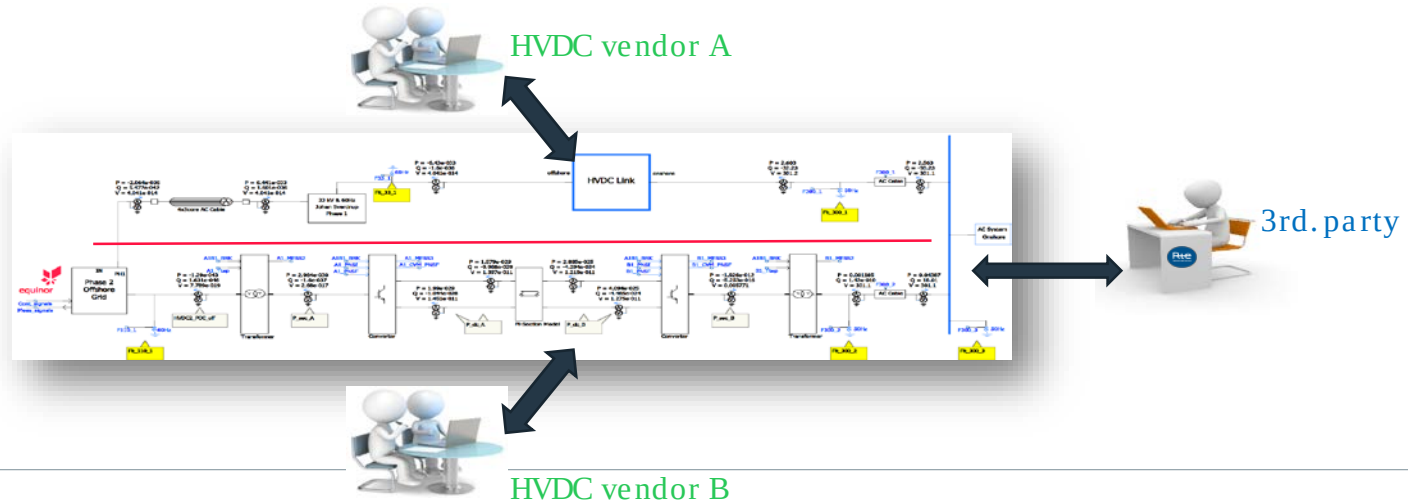
Impact of:
- offshore generation (voltage and frequency control)

Impact of:
- Offshore fault
- Onshore fault

Challenges with Johan Sverdrup HVDC links

- HVDC manufacturers supplied the EMT black-boxed converter models for the 3rd party studies
- RTE-International is performing the parallel operation studies *(offline studies & real time studies with the HVDC C&P replicas)*
- Challenges with verification, access or tuning of the control parameters to resolve the interaction issues

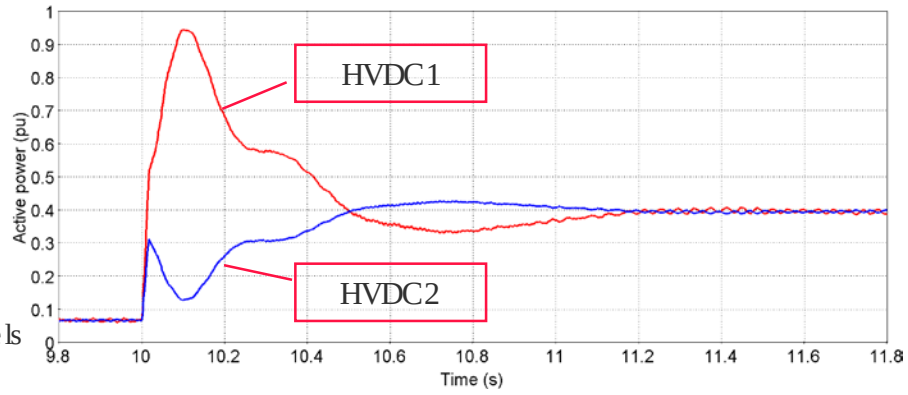
  - No direct communication between the HVDC manufactures, due to competition and regulatory policies in EU
  - Limited exchange of technical information is only possible through 3rd parties
  - Long and painful processes for implementation and testing of new converter control strategies through 3rd party

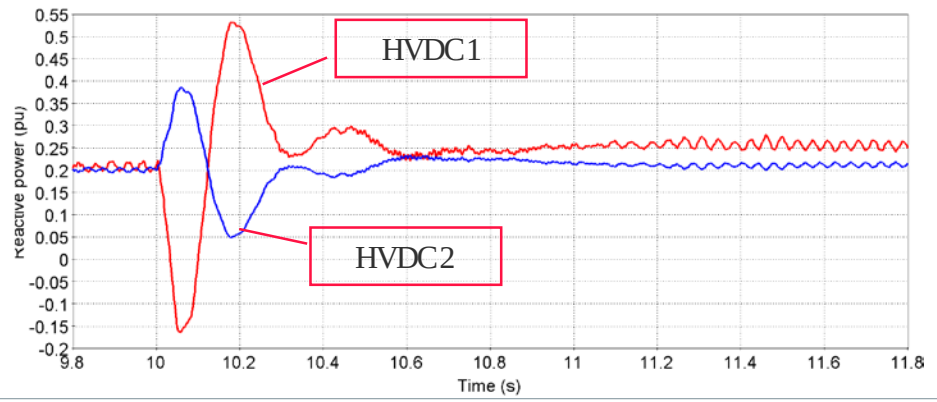


Challenges with the multivendor, multiterminal HVDC configurations

- Due to confidentiality and intellectual property right (IPR) issues, HVDC manufactures only share black-boxed models of their systems with limited access to EMT model parameters
- No Party has the full picture of the system:
  - HVDC manufacturers receive simulation results but cannot reproduce the interactions
  - The 3rd Party (RTEi) does not have access to the internal details of C&P systems to analyse interactions
- Some interaction studies require understanding of the internal converter control strategies, (simulation results depend on the EMT model accuracy)
- Small-signal stability and state-space analysis to determine the converters control interactions cannot be performed with black-boxed EMT models
- Difficult to analyse and tune the non-accessible model parameters in case of interaction phenomena

Results obtained with generic models to illustrate adverse interactions

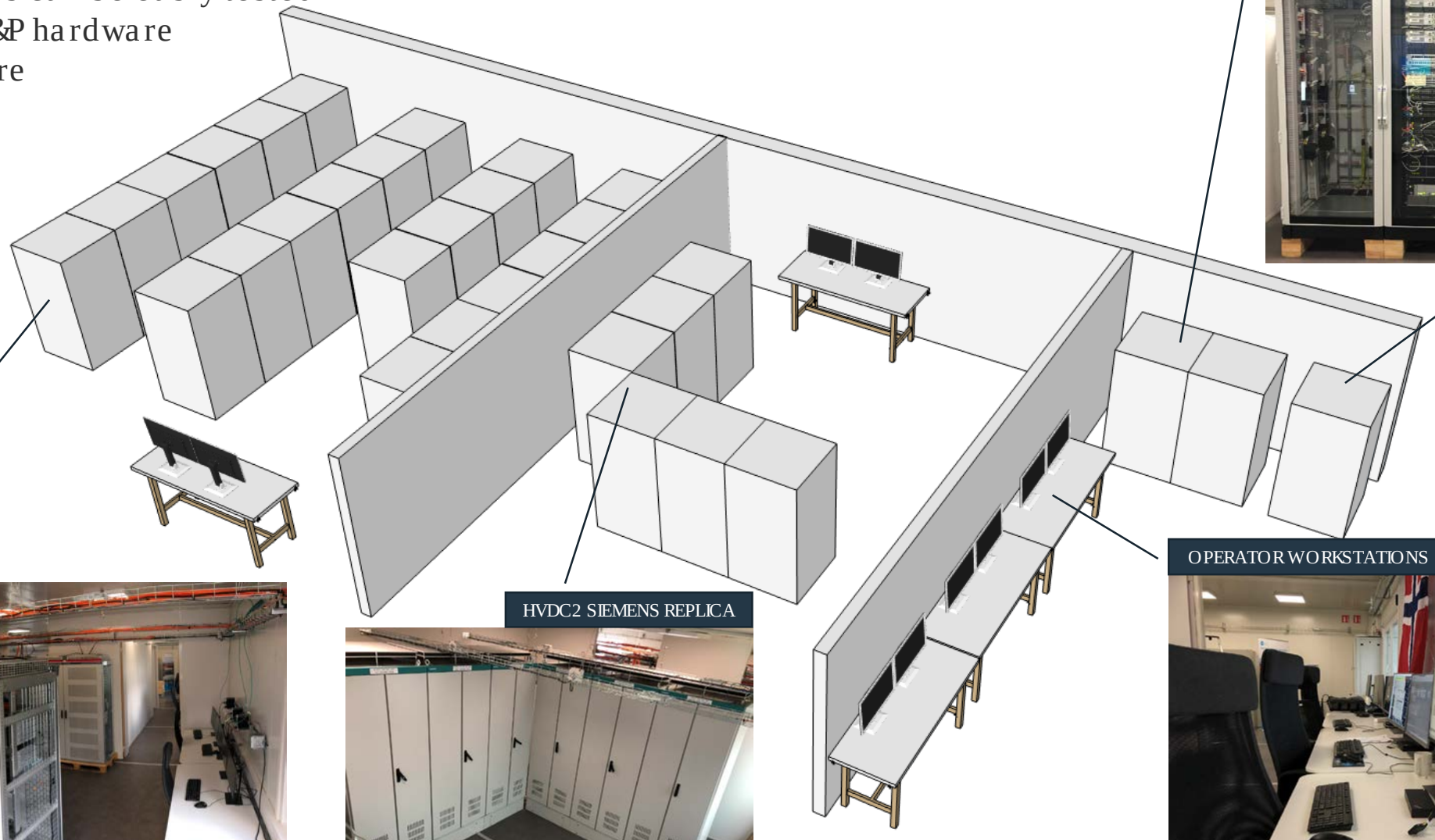




Real time lab facility to de-risk JS parallel operation

Main advantages:

- Vendors have full access to their C&P system in parallel operation
- Software updates can be easily tested
- Exact copy of C&P hardware
- Real C&P software



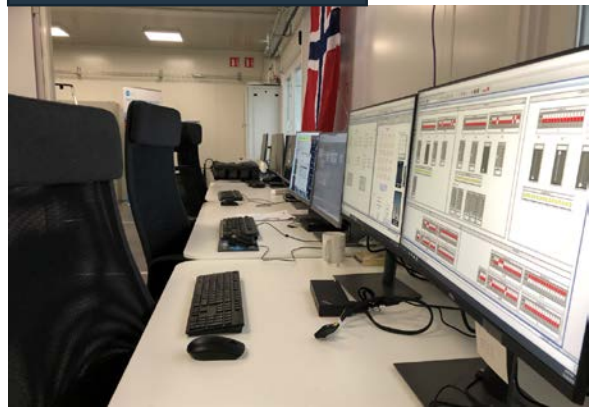
PDCS/PMS KM REPLICA

Sync Relay and RTDS

HVDC1 ABB REPLICA

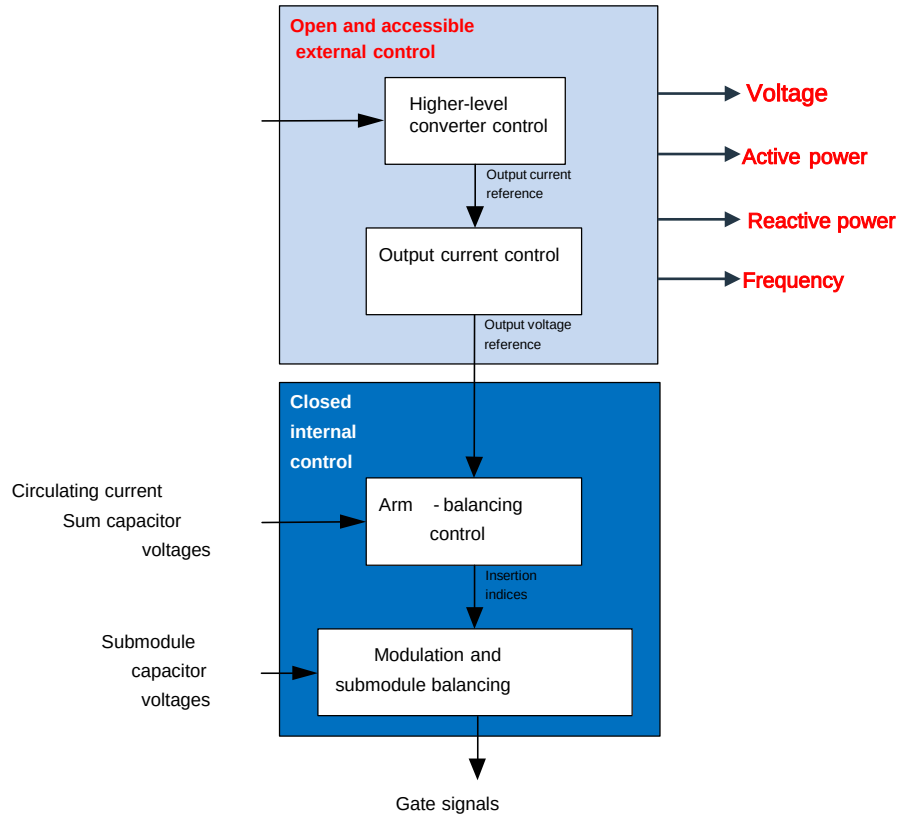
HVDC2 SIEMENS REPLICA

OPERATOR WORKSTATIONS

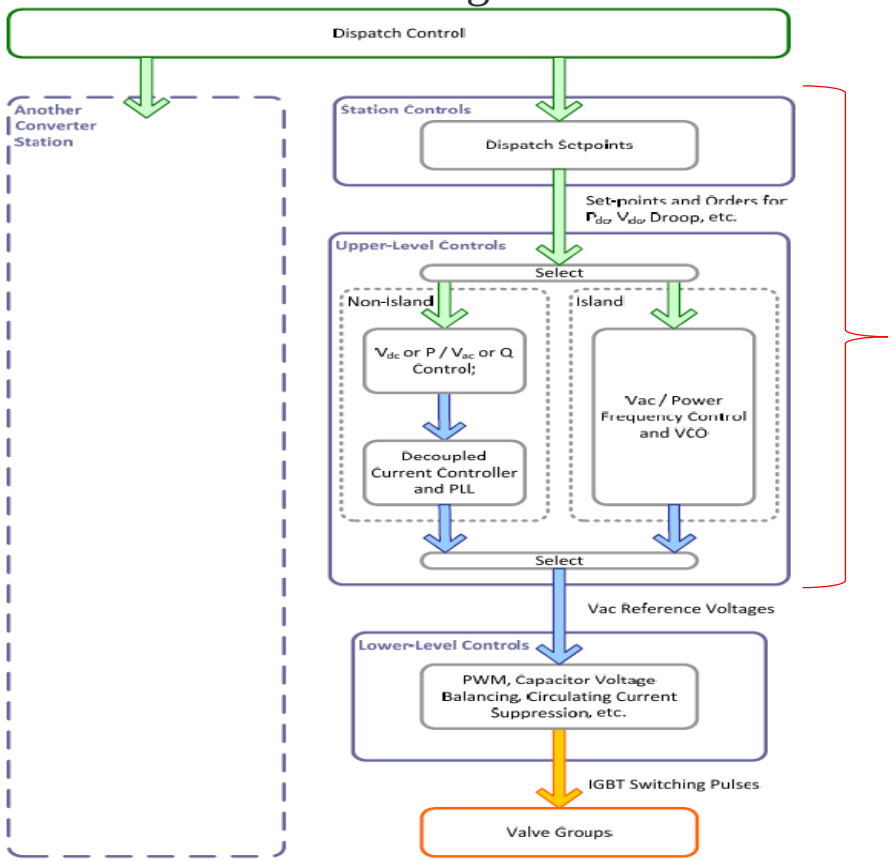


Proposal for open source converter controls

Proposal for open source outer converter control



CIGRE guide 604

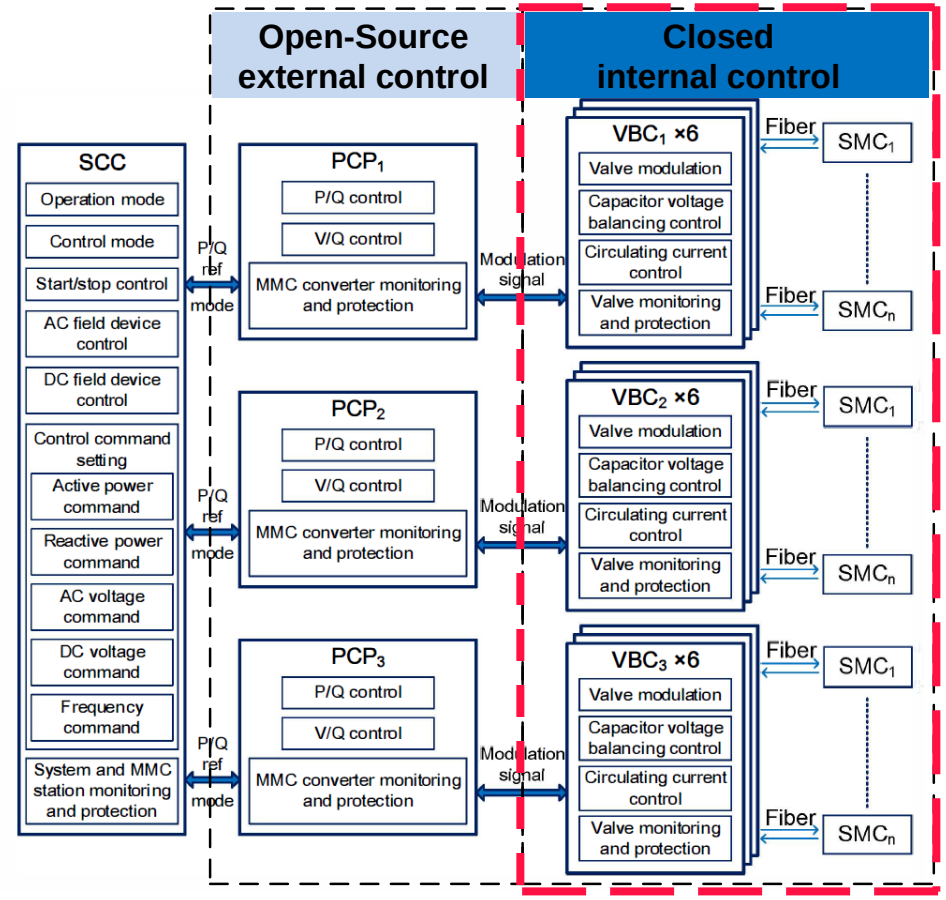


Accessible Converter Controls & Parameters P,Q,F,V

It should be noted that the protections have also a major impact, but not included in the proposal.

MTDC converter control collaboration, recommendations from Best Paths

- The control system can be split into dispatch, station, upper-level, and lower-level control.
- An open implementation of the high-level dispatch and station controls at the system level can be performed in a common master controller.
- Best Paths, multivendor experiment highlighted that the use of such a master controller enhances interoperability.



Source : ISGT Europe 2019, **A Proposal for Open-Source HVDC Control**

Final remarks

- Once upon a time Europe had the leading position in the development of VSC-HVDC technologies
- China has taken a leading position for multivendor multiterminal HVDC projects, due to open and close collaboration between the manufactures, consultants and academia
- Collaboration and combined efforts between European HVDC manufactures should be encouraged by the EC policies and regulation, in order to overcome the obstacles with development of multivendor, multiterminal DC systems in Europe

The European power system is in transition with large integration of converter dominated power generation, FACTS and HVDC links. This transition pose challenges to the stable operation of the power system. Stability analysis to avoid adverse interaction phenomena between the grid components and converters require better understanding of the internal strategies of converter controls. New methods, tools and close collaboration between vendors, academia and consultants are required to ensure the successful transition.