DC CBs for offshore DC grids

equinor

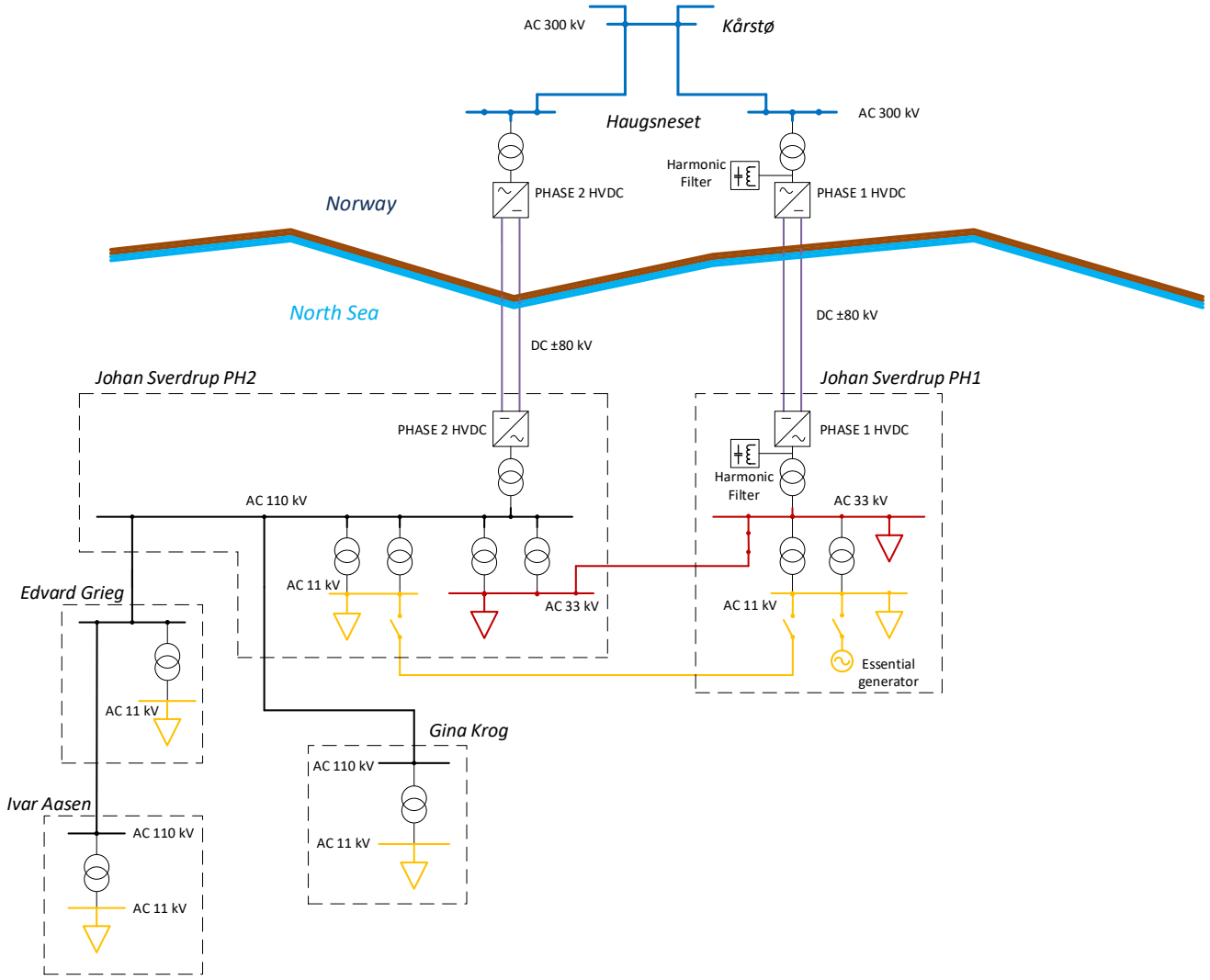
Interconnected HVDC systems

Johan Sverdrup Field Centre – North Sea (≈200km off the coast of Norway)

- HVDC Phase 1 - 100 MW
- HVDC Phase 2 – 200 MW
- Different HVDC vendors
- Different HVDC technologies
- Long 110 kV AC cables to consumers

Challenge:

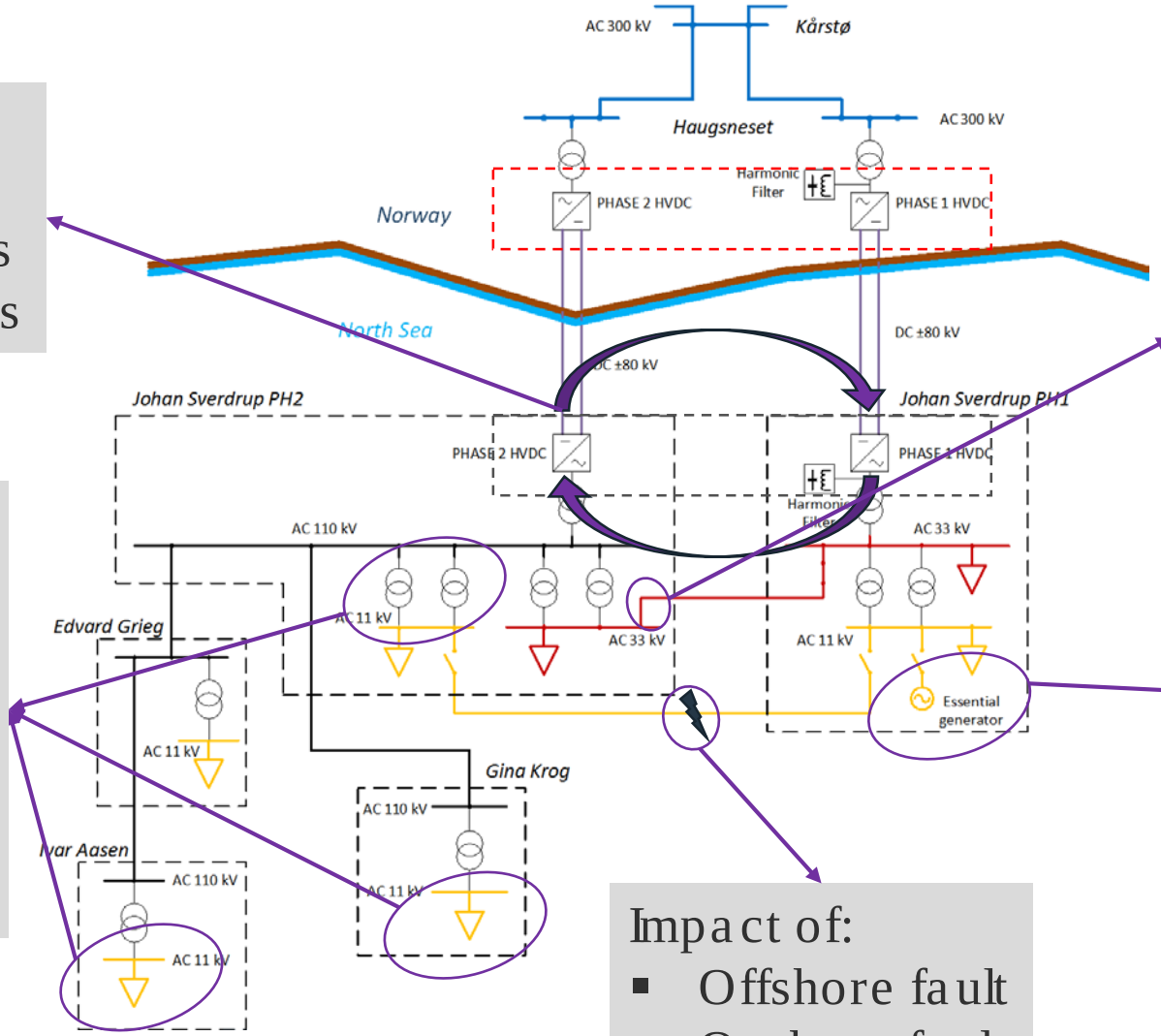
Manage system, control and other interactions between the Phase 1 and Phase 2 converters in a weak industrial grid



Phenomena of Interest with focus on interaction

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

Impact of:
- Load characteristics to voltage stability
- Energisation 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 multivendor multiterminal HVDC configurations

- Due to IP issues, HVDC manufactures only provide black-boxed models of the converter controls
  - small-signal stability and State-space analysis to determine the control loop interactions can not be performed.
  - Difficult to tune and study the non accessible parameters in case of interactions
- Simplified VSC equivalent model representations, negligate's the behavior of VSC in high frequency ranges
- Frequency ranges to capture the behavior of various passive components are not well established.
- EMT converter models don't capture in detail actual C&P functions e.g. startup sequences

In the first stage the focus should be to resolve technical issues related to multivendor multiterminal HVDC grids

DC circuit breakers for offshore implementation

- Weight and volume of the available DC breaker technologies are an obstacle for utilization in offshore platforms

- At current stage HVDC manufacturers do not provide access to C&P systems for 3rd. parties

- Reliability of DC protection systems in DC grids are not verified, hence industrial application of the technology will be limited

At the current stage Industrial offshore utilization of available DC CB technologies cannot be justified due to cost, weight, volume, reliability

Final Remarks

- What will be the actual cost, weight and volume of DC breakers?
- Based on the DC breaker patents and vendors, there will be no real competition. Selecting a breaker technology will bind the purchaser to a single source.
- What will be the reliability and availability of DC fault protection technologies?
- Multivendor DC breakers and HVDC converters in a DC grid is not foreseen as option, due to availability guaranties, exchange of technical data, ...etc.
- Alternative DC fault protection technologies, e.g. FCLs, full-bridge converters vs. half-bridge converter is evaluated to be more realistic.

Which DC fault protection technology at which cost will be the best alternative for offshore DC grids?