InterOPERA 1st technical workshop

Demonstrator definition & system design studies

Inter OPERA
Enabling multi-vendor HVDC grids

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14.03.2024

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Agenda

- Outcomes of Task 3.1: Demonstrator definition & system design studies
- Definition of the InterOPERA demonstrator
  - Presentation of results
  - Discussion
- Preliminary conceptual system design studies
  - Presentation of results
  - Discussion

Introduction

Main outcomes of T3.1

- Work package description:

The goal of this task is to define a demonstrator project, to provide an overall understanding of the foreseen and planned multi-terminal multi-vendor (MT-MV) HVDC systems, and to provide guidance from the asset owner / TSO perspective.

A second version of D3.1 will include the preliminary conceptual DC grid system design studies

Main outcomes:
I) Definition of the InterOPERA demonstrator
II) Preliminary conceptual system design studies

Deliverable publicly available!

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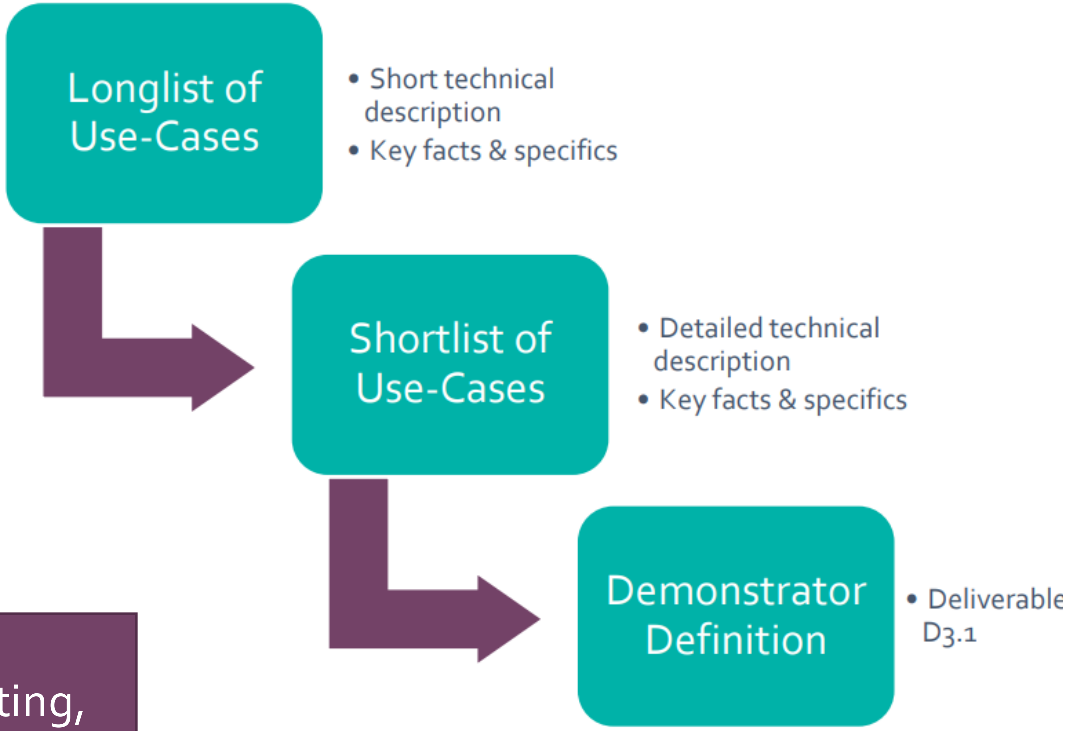
Definition of the InterOPERA demonstrator

Process description of the demonstrator definition

- Longlist of currently planned HVDC use-cases in Europe
- Shortlist of generic use-cases based on key characteristics of the longlist entries
- Assessment of the key characteristics and definition of the Demonstrator topology



<u>Key characteristics:</u>
525 kV, Bipole with DMR, 2 GW power rating, DC-FSDs, stand-alone DC switching station, two synchronous areas

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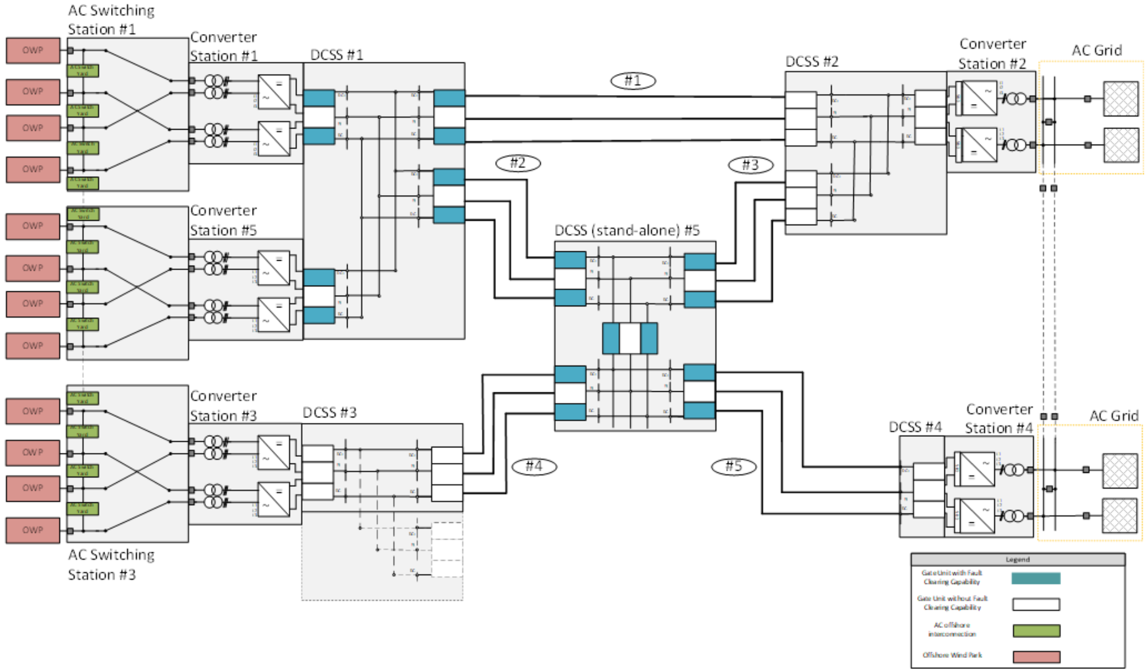
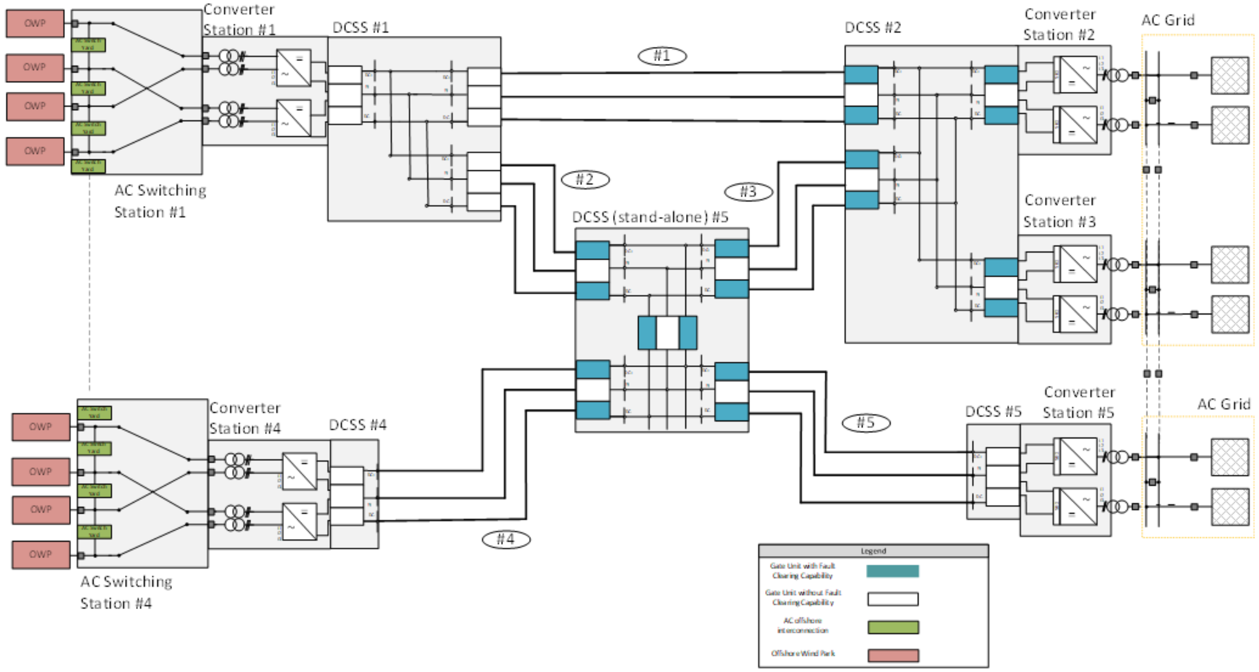
InterOPERA Demonstrator

Meshed offshore grid for wind export (Demonstrator variant 1)



Meshed multi-purpose hybrid interconnector (Demonstrator variant 2)



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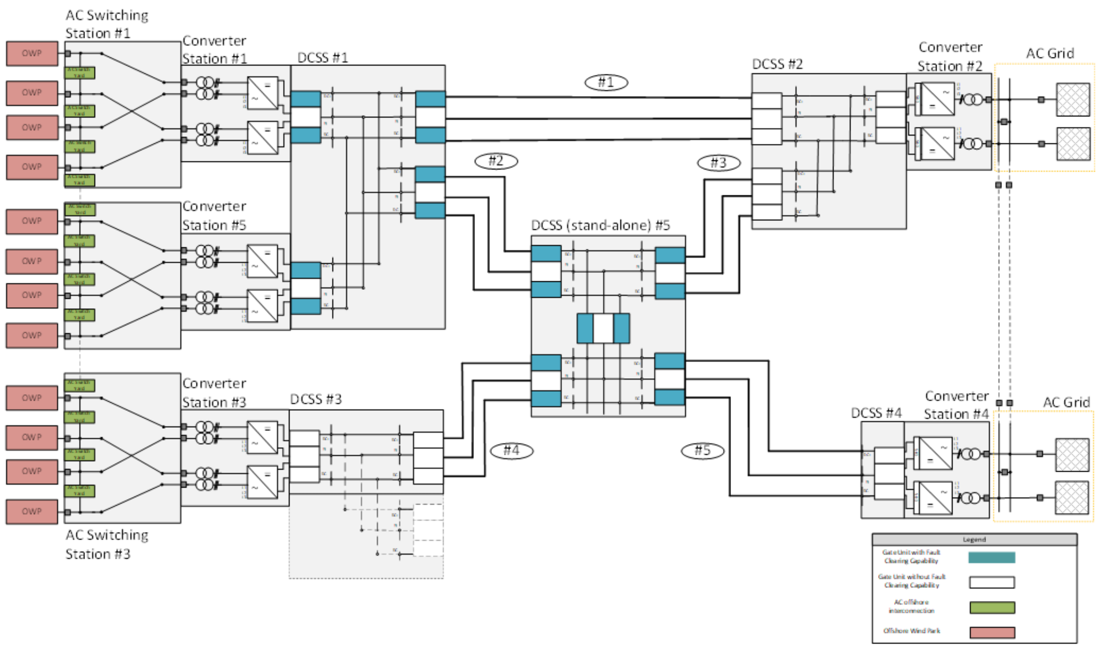
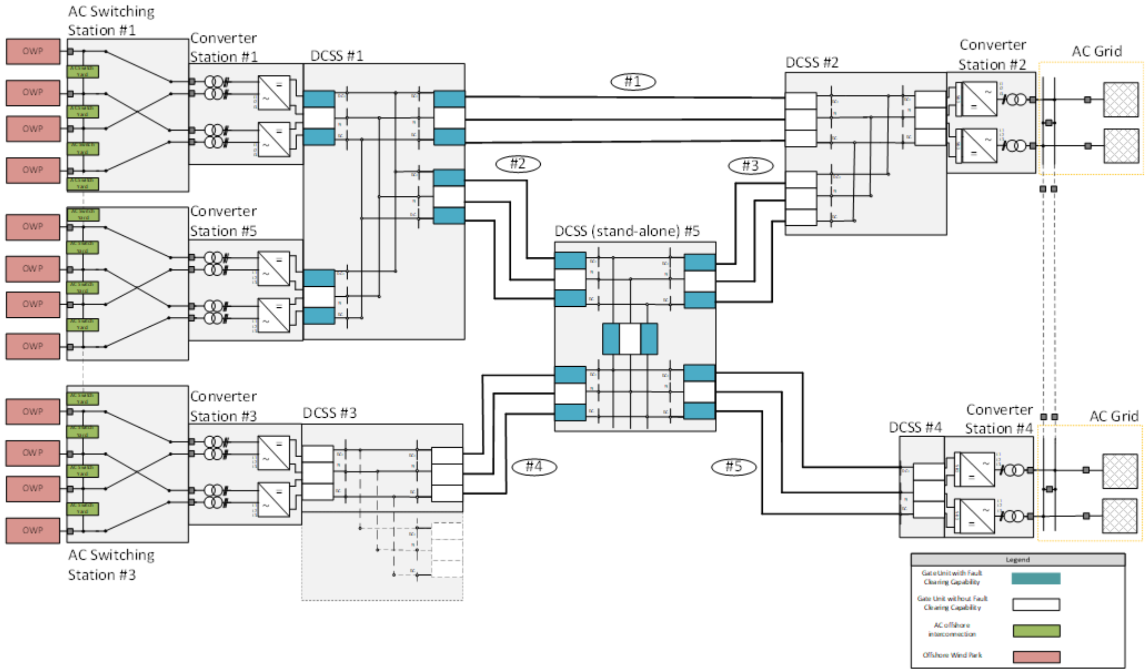
Characteristics: General topology

- Two converter stations at the same DC busbar connected in close electrical vicinity
- Stand-alone DC switching station
- DC switching station including a DC-FSD in the longitudinal coupling
- Long distance DC transmission cable
- Integrated DBS at the onshore converter stations
- Multiple HVDC operation modes including bipole with DMR, rigid bipole & asymmetrical monopole



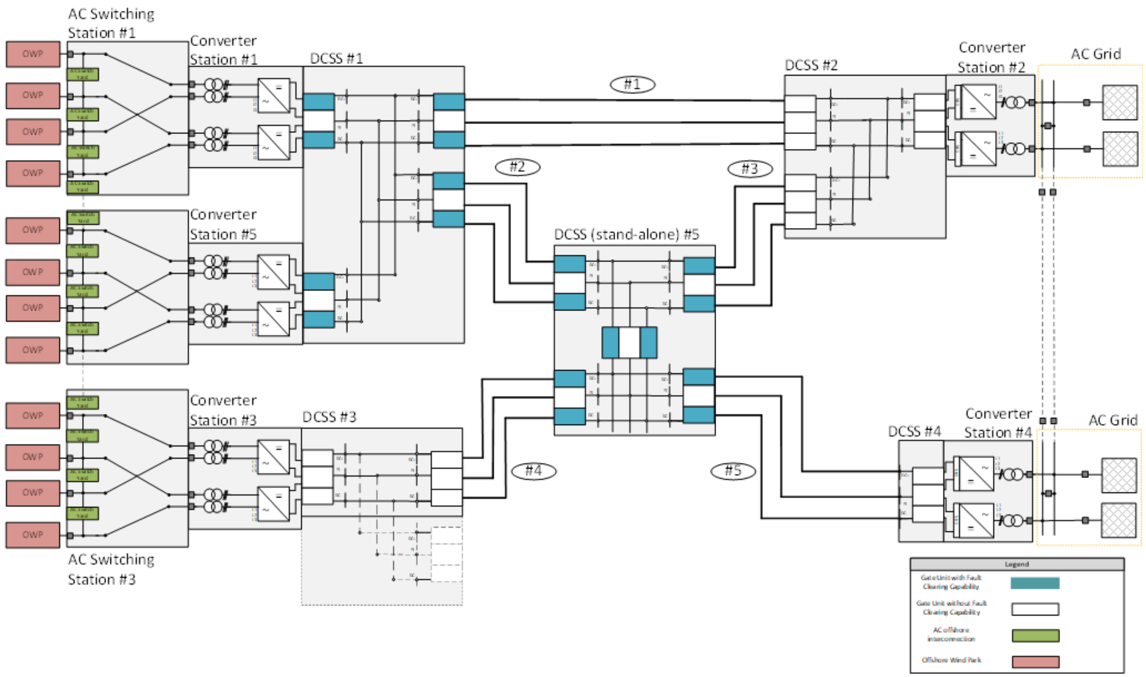
Characteristics: DC grid protection

- Primary & back-up protection sequences using DC-FSDs
- Double-ended protection sequences using DC-FSDs
- Primary & back-up protection using DC-FSDs in meshed DC grid configurations
- Different types of DC switching stations - offshore and onshore

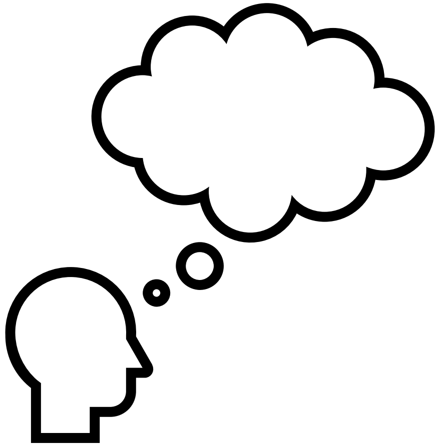


Characteristics: Grid forming

- Two different synchronous AC onshore grids
- Possibility to connect different HVDC converter station vendors at the same DC busbar
- Possibility to AC couple different PPM manufacturers



Discussion regarding the demonstrator definition



What are key characteristics of multi-terminal grids around the North Sea?

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Mentimeter code: 5506 4539
Link: https://www.menti.com/alacwt2ahpqs

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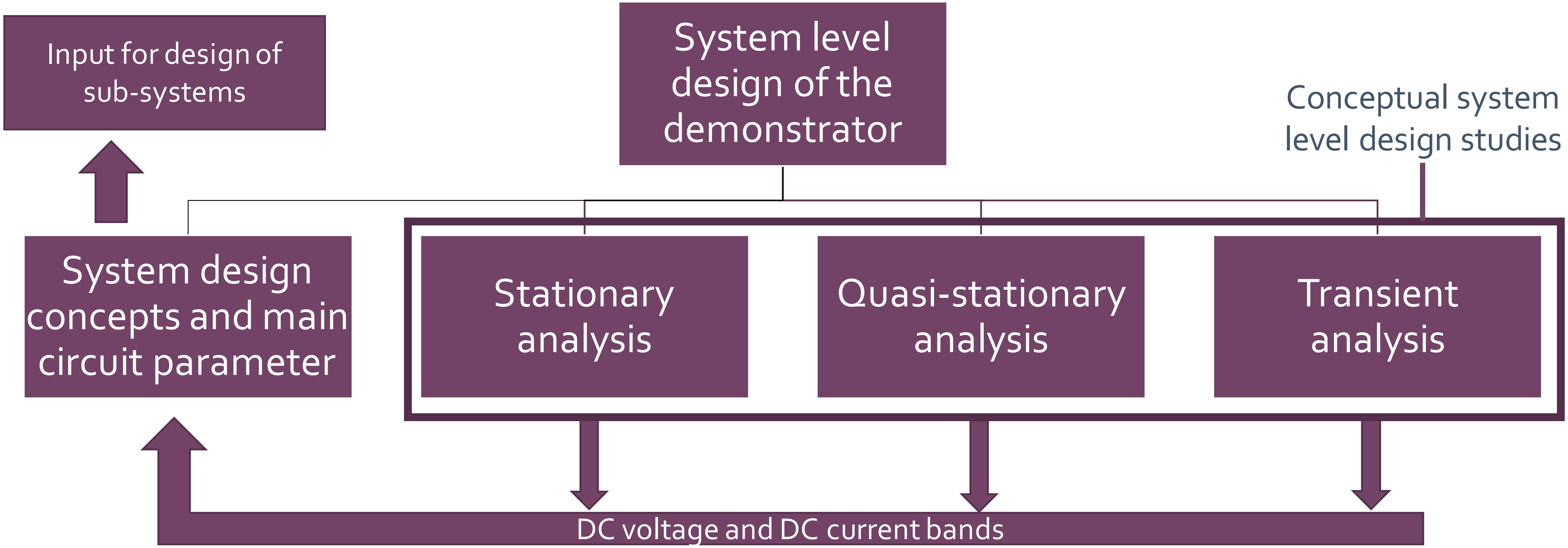
Preliminary conceptual system design studies - Overview

System design of the demonstrator - Conceptual system level design studies



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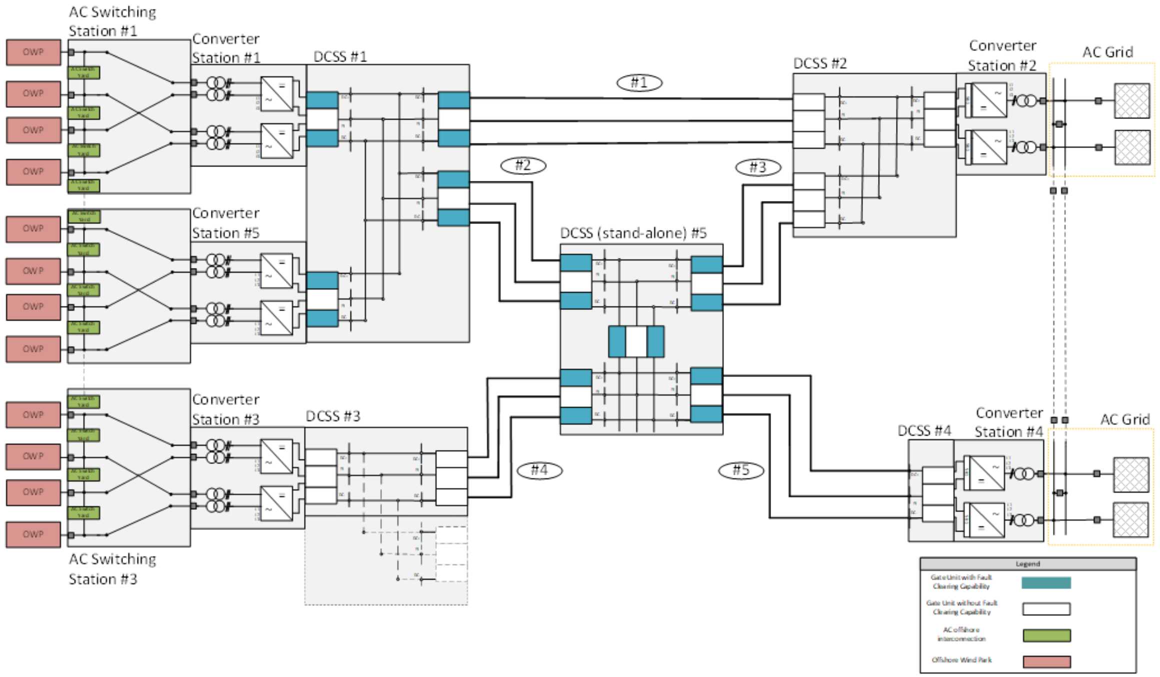
Stationary analysis

Objective of the study
Derivation of a stationary DC voltage and DC current band

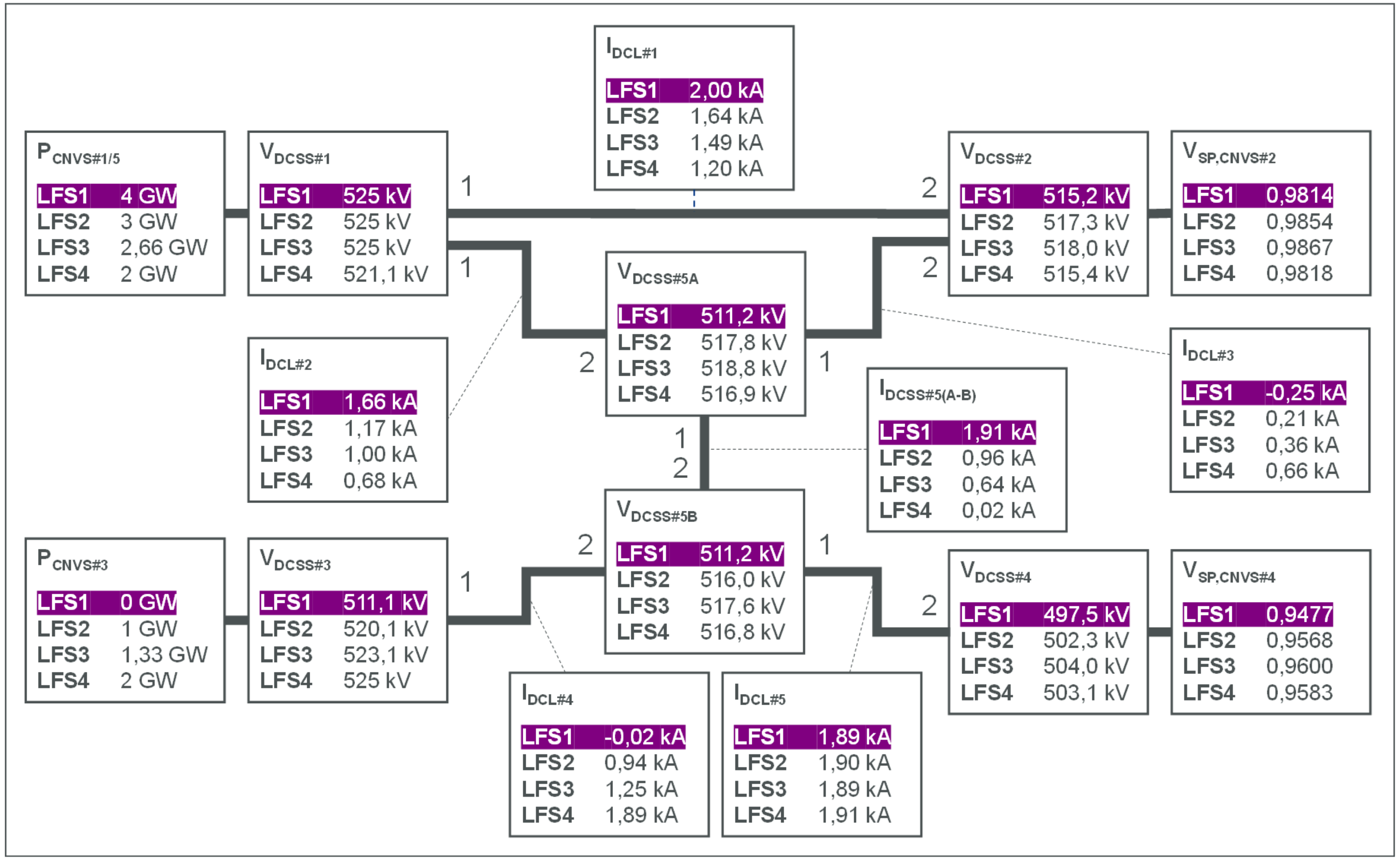
Objective

- Definition of **a stationary DC voltage** and **DC current band** for the offshore and onshore converter stations based on:
  - A) Assumptions for:
    - DC-system data (cable parameters)
    - DC-FSD losses
    - Converter losses
  - B) Identification of design relevant load flow scenarios



Identification of design relevant load flow scenarios

- Simulation of different load flow scenarios
- Identification of design relevant load flow scenarios
- Derivation of stationary DC voltage bands for onshore & offshore converter stations and DC switching stations



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Quasi-stationary analysis

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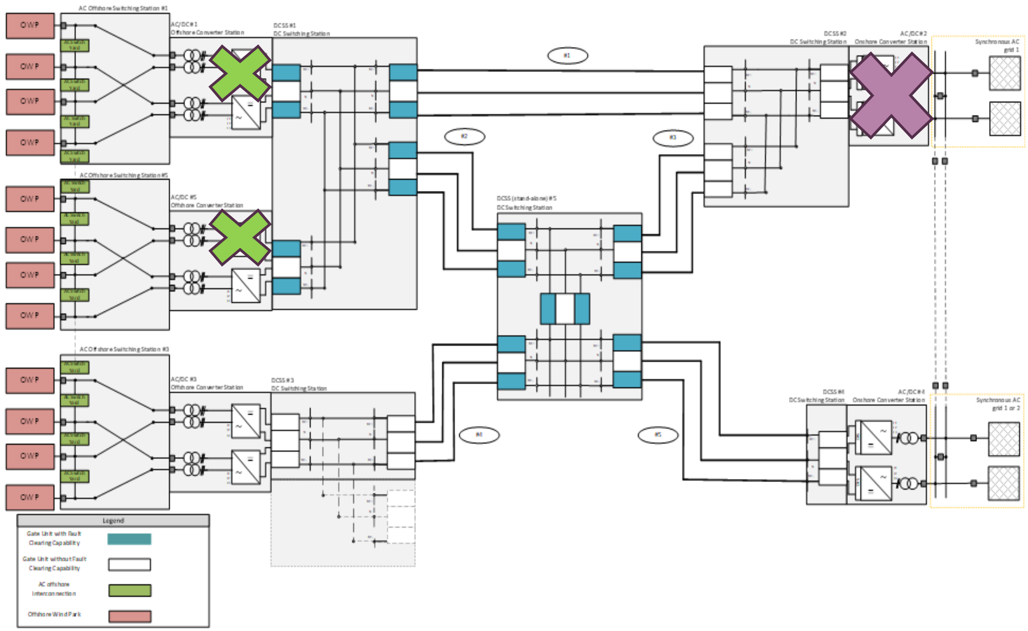
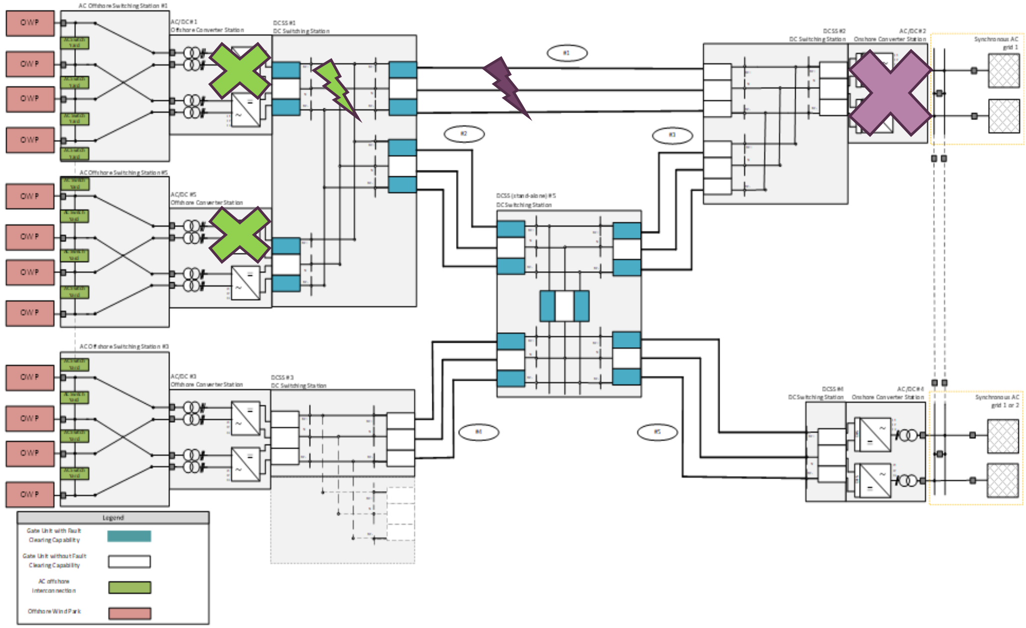
Objectives of the study
Derivation of a temporary DC voltage and DC current band

- Definition of **a temporary DC voltage** and **DC current band** of the offshore and onshore converter station based on:
  - A) Assumptions based on
    - AC and DC system data
    - Converter parameters
    - Control parameters including droop parameters
    - DC-FSDs
  - B) Design relevant contingency scenarios



Design relevant scenarios loss of infeed and loss of load

- Focus on design relevant scenarios
  - Loss of infeed:
    - Loss of 2 GW infeed for one pole
    - E.g. caused by a pole to ground fault in an offshore DC switching station
  - Loss of load:
    - Loss of an onshore converter station
    - E.g. caused by a pole to pole fault in a bundled offshore cable



Conclusion
Definition of a temporary DC voltage band

- Considering both scenarios, preliminary temporary[1] DC voltage and DC current bands are defined

Loss of infeed scenario: Minimum temporary DC voltage + Loss of load scenario: Maximum temporary DC voltage = Temporary DC voltage band

1: temporary = max./min. values during the primary DC voltage control response but before secondary DC voltage control

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Transient analysis

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Objectives of the study
Derivation of transient DC voltage and DC current bands + dissipated energies

- Derivation of **a transient DC voltage and DC current band** for the offshore and onshore converter units
- Assessment of the **max. dissipated energies** in the DC switching station with an DC-FSD

Calculations based on:

- critical fault types and fault locations
- constraints
- Assumptions for AC/DC system data, converter stations, DC-FSDs, ...

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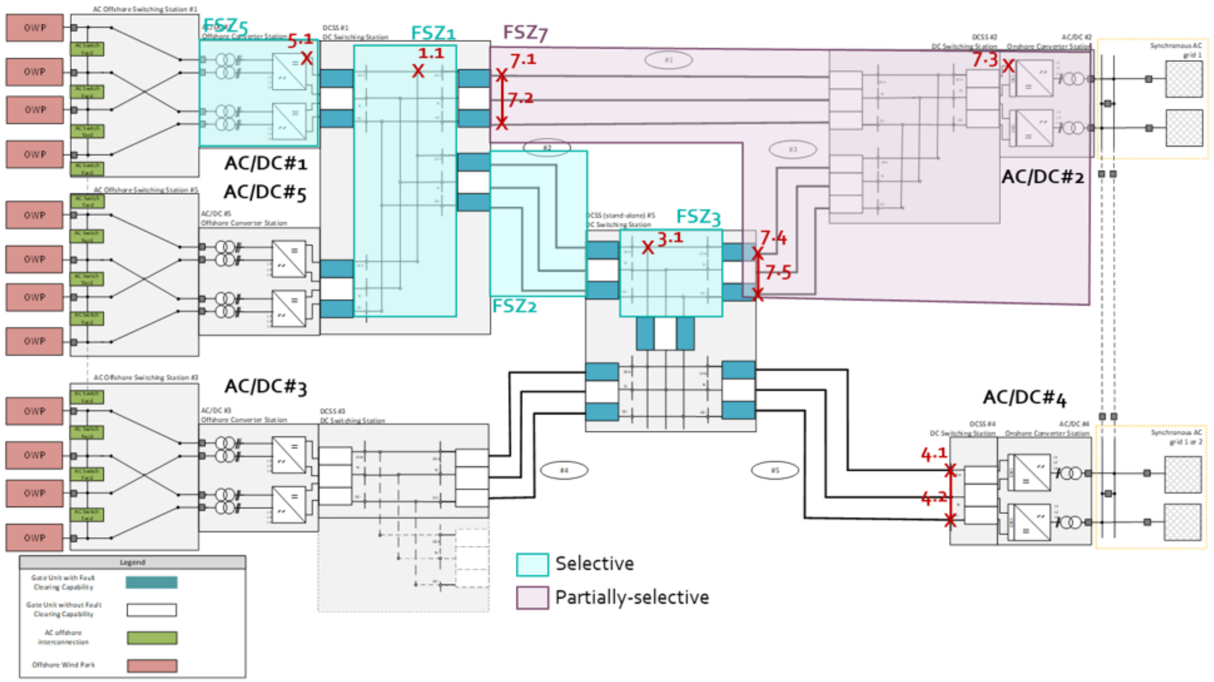
Methodical approach

- Simulation of short circuit events for various combinations of fault locations and constraints
- Considered constraints:
  - Converter capability: Variation of the overcurrent threshold
  - DC switching station capability: Variation of the total inductance in a DC switching station
  - Variation of the fault neutralization time
- Assessment of the transient stresses expected for a combination of constraints



Discussion regarding the conceptual system design studies

What should be key outcomes of conceptual system level design studies performed by the asset owner?

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Thank you very much for your attention!