



PROMOTiON

PROGRESS ON MESHED HVDC
OFFSHORE TRANSMISSION
NETWORKS



WP2 – Grid Topology & Converters

Intermediate Conference Amsterdam

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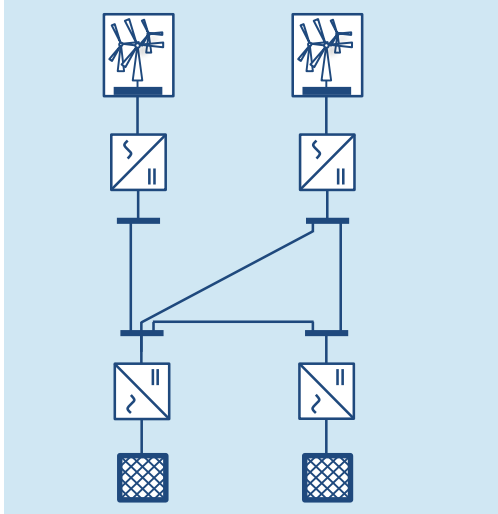
CONTENT

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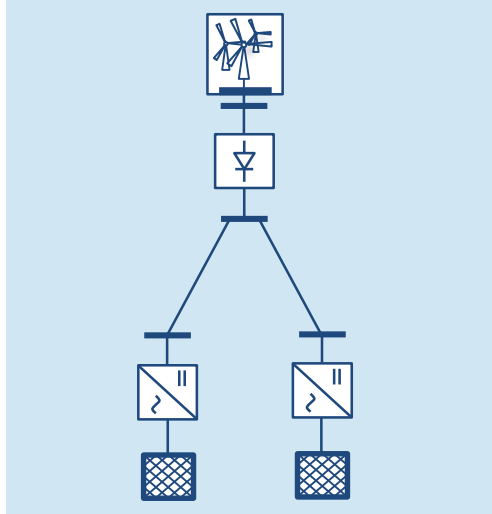


Objectives of WP 2

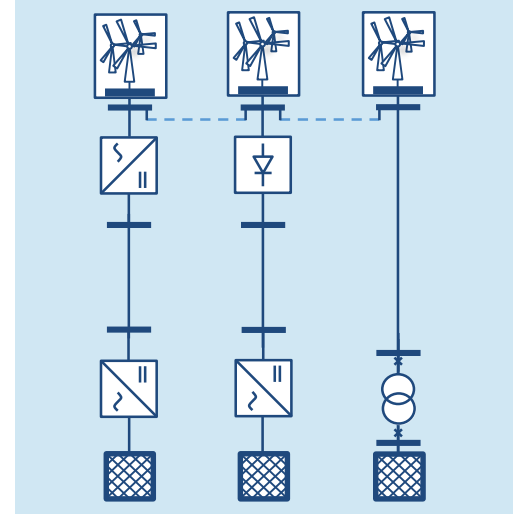
Trade-off analysis of different topologies



Interconnection of VSC and DRC systems



Control concepts to ensure interoperability



To define recommendations on onshore and offshore power systems for existing grid codes



Topologies



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Evolution of HVDC topologies in Europe

Type of topology:

Existing

LCC-Links

VSC-Links for

- Grid reinforcement
- OWF connection
- Interconnectors

Planned

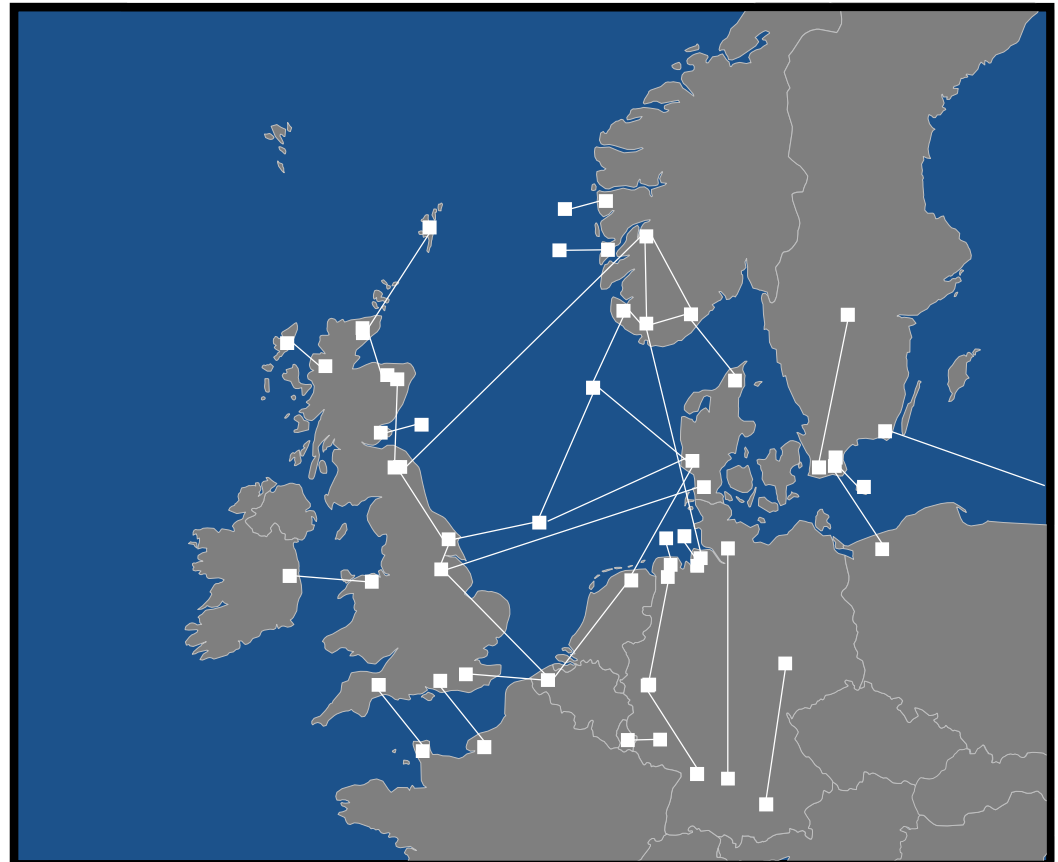
Radial VSC Multi-terminal systems

Future

Meshed VSC Multi-terminal systems

DC Overlay grid

Schematic representation: VSC based HVDC systems



Challenges due to topology development

Normal Operation & System Design

- DC voltage level
- DC configuration
- Operational strategy
- Interoperability

Role of Offshore Wind Farms

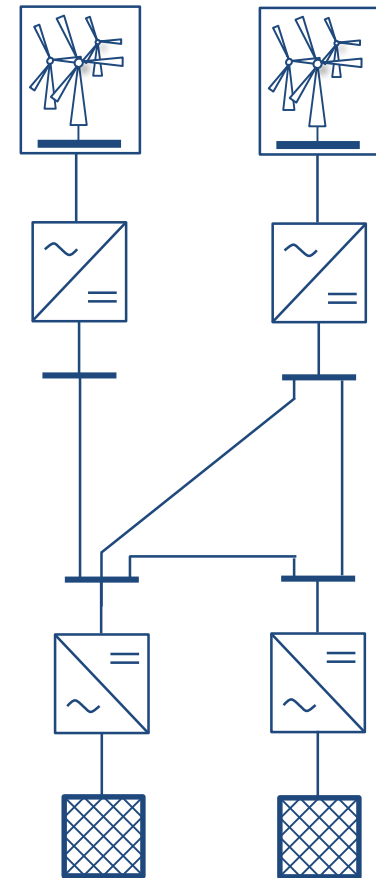
- New requirements?
- Use of control capabilities for AC and DC FRT

DC side faults and contingencies

- Reliability and availability criteria
- Impact of faults and fault clearing strategies

AC system dynamics

- Provision of ancillary services
- AC FRT of the overall system
- Respect the different frequency reserves





Converters



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Converter types & models

State of the art MMC-systems

- Half-bridge based
- Symmetric monopolar configuration

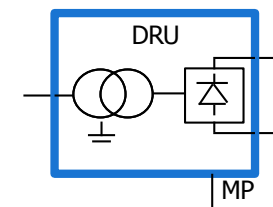
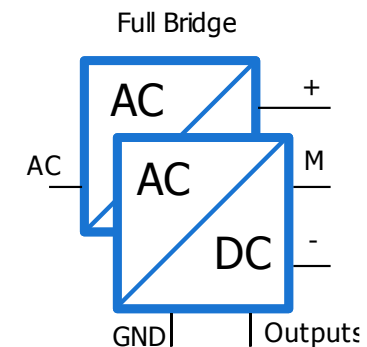
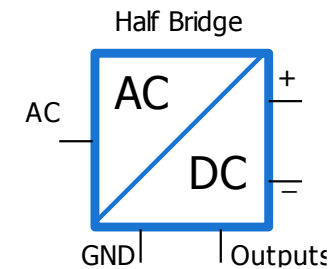
Planned systems

- Full-bridge based
- Bipolar configuration

Under development

- Diode rectifier based HVDC systems
- Combinations of the given systems

EMT-Models



Converter controls

EMT models based on Cigré

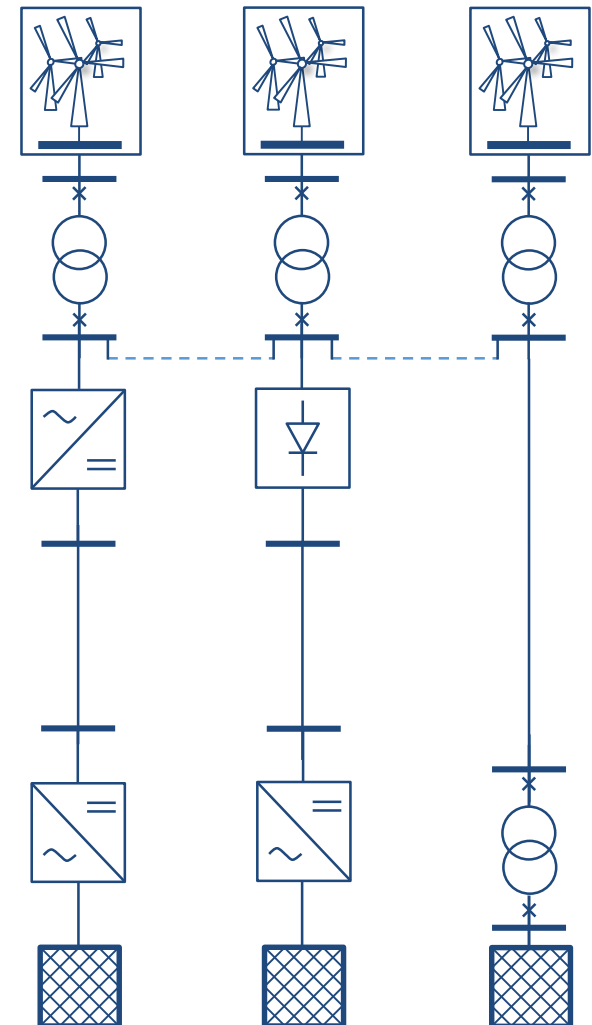
- Adaption for different configurations, topologies and models

Enhancement of controls

- Studies on combined wind farms and DC grid models
- Grid forming and grid following controls for wind farms
- Frequency support strategies

DRU controls

- From energization to fault operation
- Combination in different grid layouts
- Technical interoperability of different converter types and controls





Studies & Results



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Overview Studies

Normal Operation & System Design

- Optimal power flow with different objectives
- Operational strategies
- Interoperability of DRUs

DC side faults and contingencies

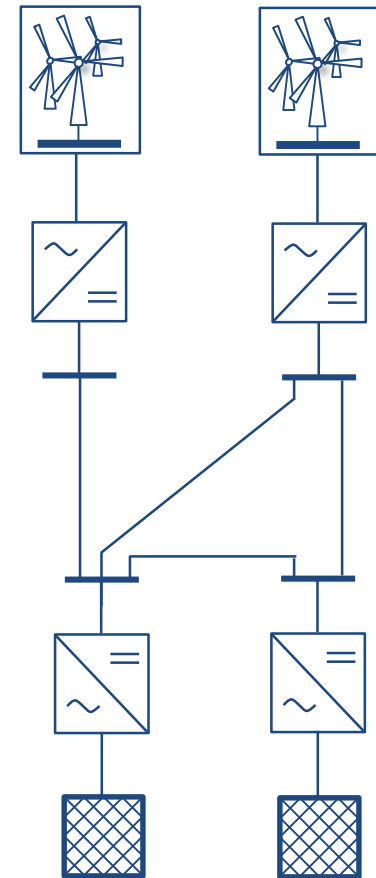
- Impact of faults and fault clearing strategies on the overall systems and its components

Role of Offshore Wind Farms

- Requirements on OWFs for various fault clearing strategies
- Use of control capabilities for AC and DC FRT

AC system dynamics

- Frequency support
- AC FRT of the overall system
- Impact of DC faults and their clearance on the AC power flow



Exemplary achievements and conclusions

- Extended converter PSCAD models have been integrated into the Cigré working group B4-69
- Operation of DRUs in different grid layouts is possible
 - From steady-state to fault operation
 - Parallel operation of grid forming and grid following wind farms
- Test of different frequency support strategies in a variation of test scenarios successful
- Different DC fault clearing strategies in the DC grid lead to different requirements for the wind farm controls



Thank you for your attention!



Technical University of Denmark

