

Wind Turbine – Converter Interaction

PROMOTiON WP3

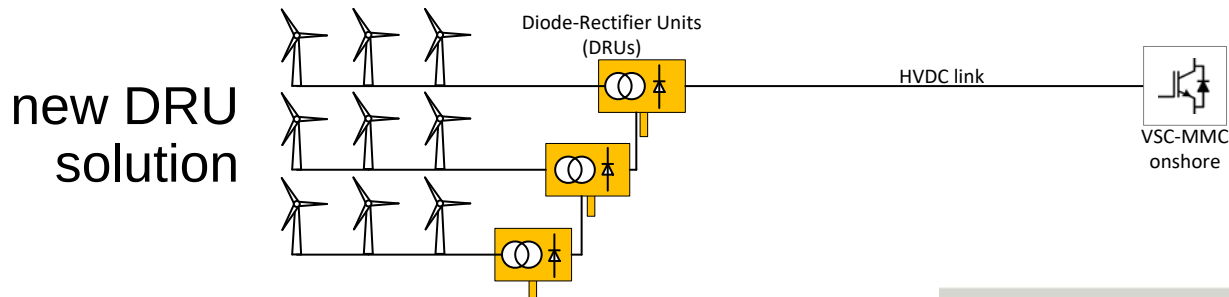
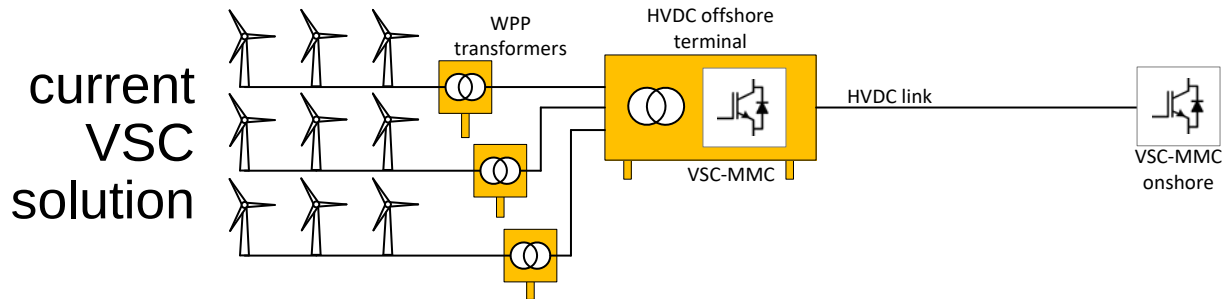
Ömer Göksu, DTU Wind Energy

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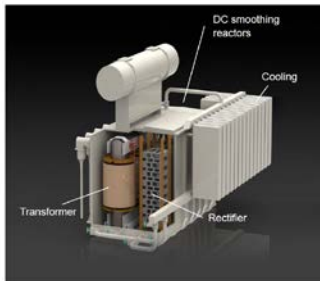
- Diode Rectifier as offshore HVDC
- Grid Forming Wind Turbines
- Offshore AC Grid Start-up
- Black Start by Offshore Wind Turbines
- Recommendations for Standards

Diode Rectifier Units as offshore HVDC



Key features of the Modular Diode Rectifier Unit

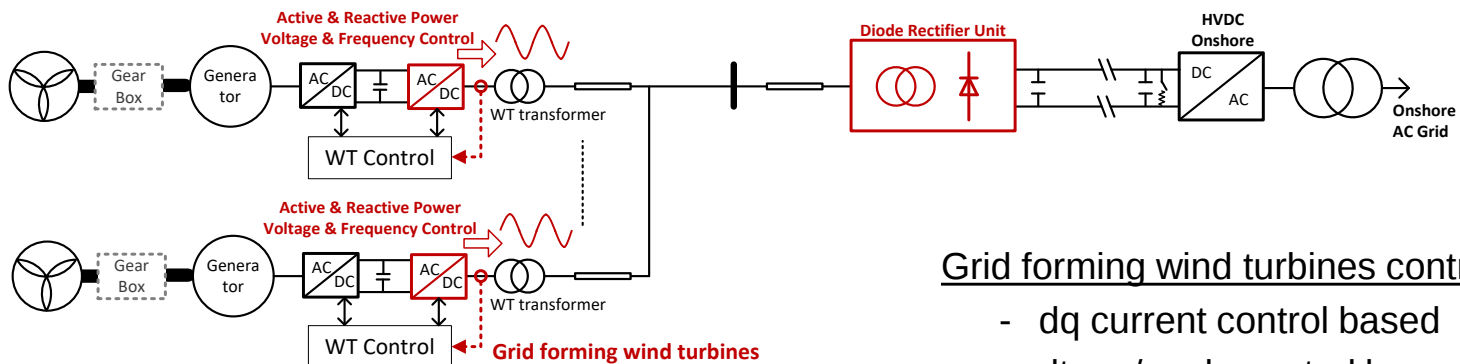
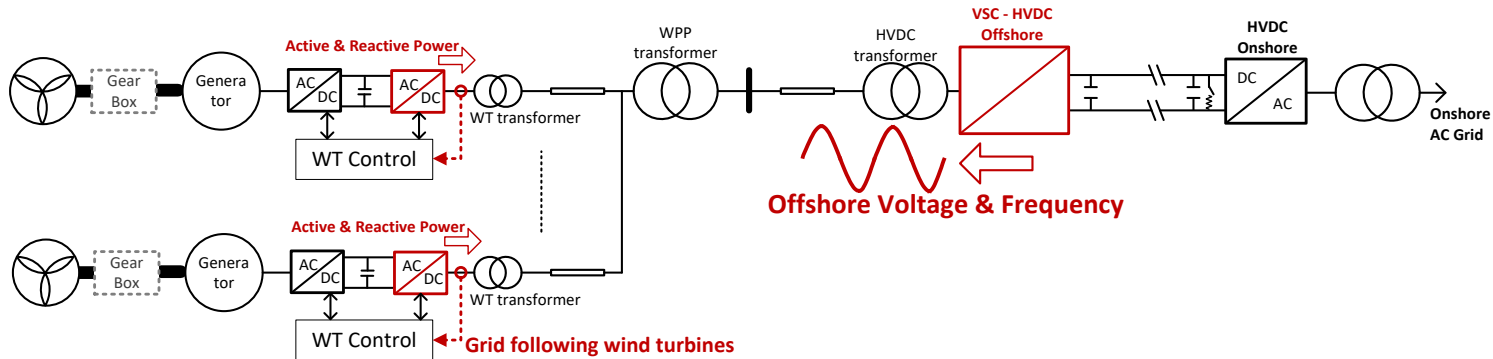
- Encapsulated, rugged equipment
- Bio degradable and flame retardant insulation
- Simple and robust power electronics
- Small platform with easy transport and installation
- High reliability, minimal maintenance
- No offshore DC converter as single point of failure
- Flexible offshore installation options due to modular rectifier concept



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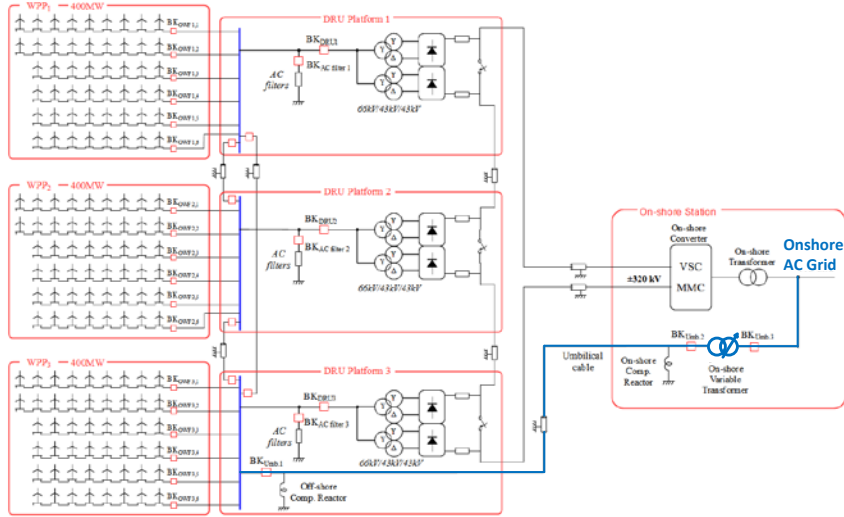
Grid Forming Wind Turbines



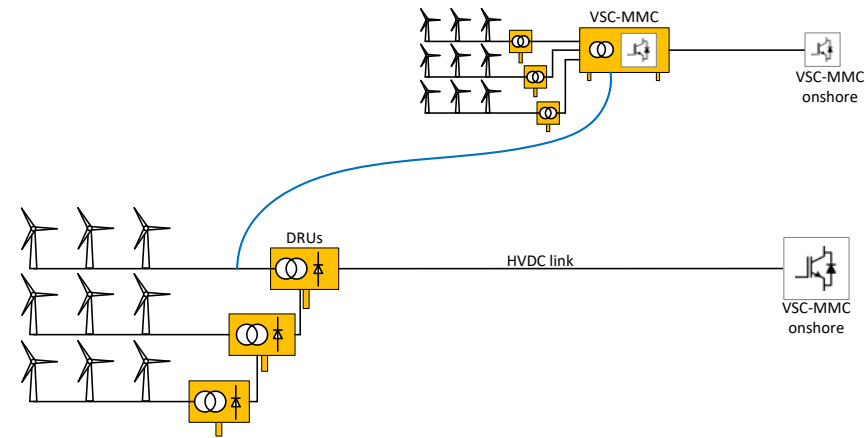
Grid forming wind turbines control

- dq current control based
- voltage/angle control based
- GPS synchronization based
- master/slave based

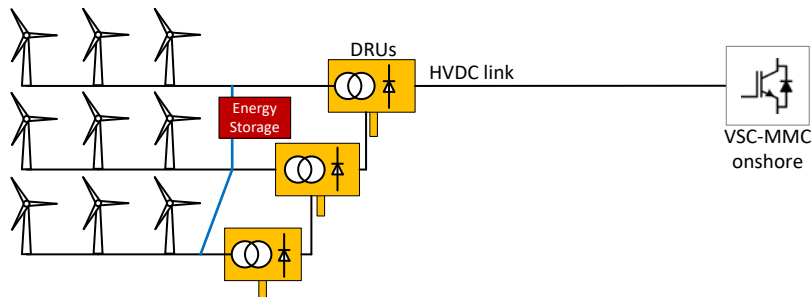
Offshore AC Grid Start-up Options



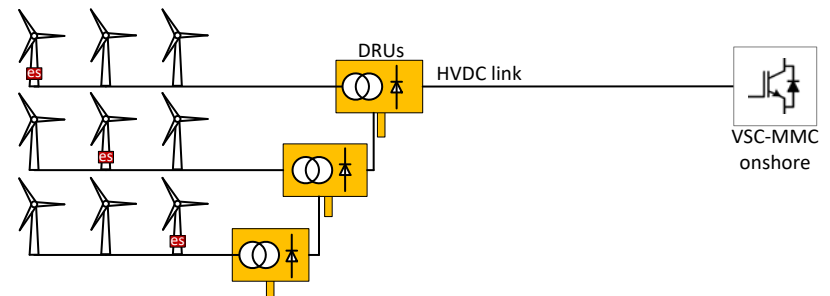
Umbilical AC Cable



Nearby VSC-HVDC (or AC)



Local Energy Storage (e.g. battery, diesel)



Black-startable wind turbines

Black Start by Offshore Wind Turbines

Objective:

To avoid issues of non-operating wind turbines;

- Moisture
- Icing
- Vibrations
- Deformation

Objective:

To energize WPP and substations' auxiliary w/o any external supply

Objective:

To provide black start for the onshore power system

Step 1 Self-start of Wind Turbine

- Wind turbines will start w/o grid voltage
- Wind turbines will supply themselves using wind (houseload operation)

Step 2 Self-Energization of Wind Power Plant

WPP will energize up to the onshore PoC

Step 3 Contribution to Grid Restoration

WPP will operate similar to the conventional black start units

Recommendations for Standards

PROMOTiON WP3: Wind Turbine – Converter Interaction

- Functional requirements to DRU connected WPPs
- General control algorithms for DRU connected WPPs
 - Fundamental operation
 - Fault response
 - Ancillary services
- Compliance test procedures for DRU and VSC connected WPPs
 - Compliance test requirements for single offshore wind turbines
 - Compliance test requirements at offshore WPP level
 - Validation procedure for simulation models
- Recommendations to adapt and extend existing grid codes
 - Paradigm shift from grid following wind turbines to grid forming wind turbines



APPENDIX

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PROMOTioN – Progress on Meshed HVDC Offshore Transmission Networks

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