PROMOTioN
PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS

PROMOTioN WP3 - Wind turbines converter interaction

Black start capabilities of HVDC connected offshore wind power plants

Poul Sørensen, DTU Wind Energy

25 September 2018, Global Wind Summit 2018, Hamburg

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691714.

WP3 – Wind turbines converter interaction

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691714.

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 (AC and HVDC) auxilary 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

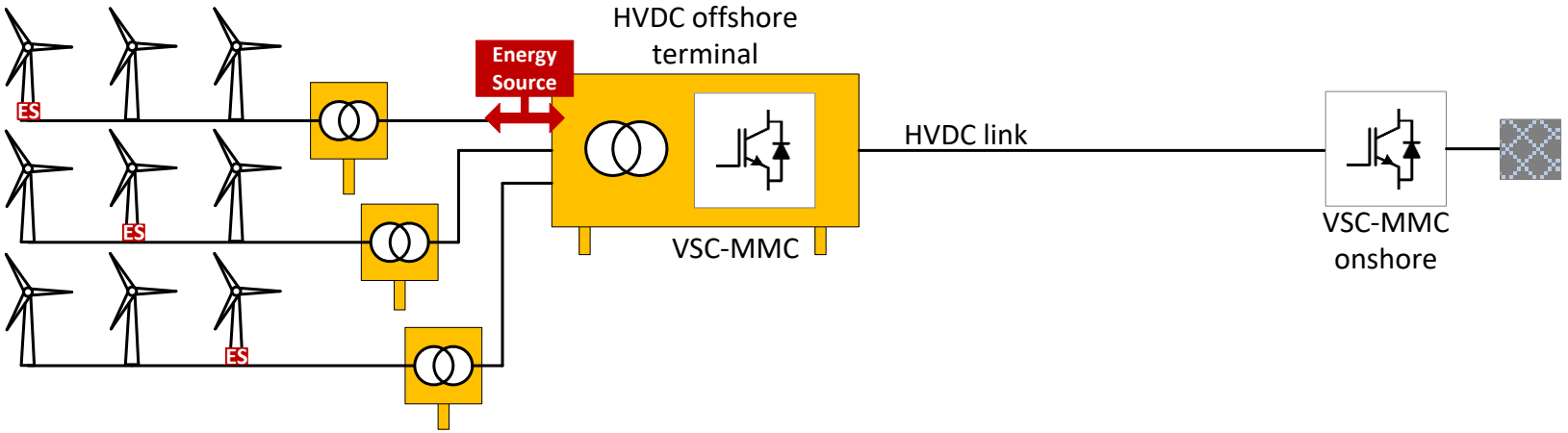
WPP will operate similar to the conventional black start units

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691714.

Offshore AC Network Start-up Options

In case of normal conditions
Energization from onshore

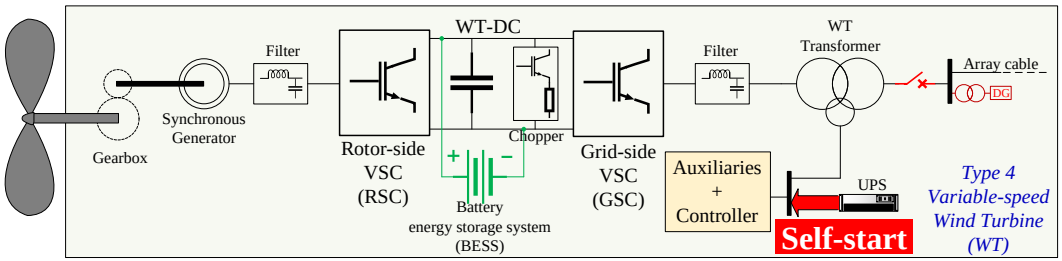
In case of offshore grid outage
Offshore Energy Source (e.g. diesel generator)



In case of offshore grid outage or collection system failure
Black-startable wind turbines

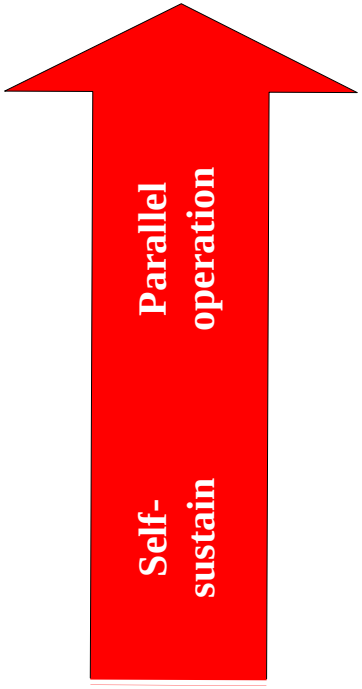
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691714.

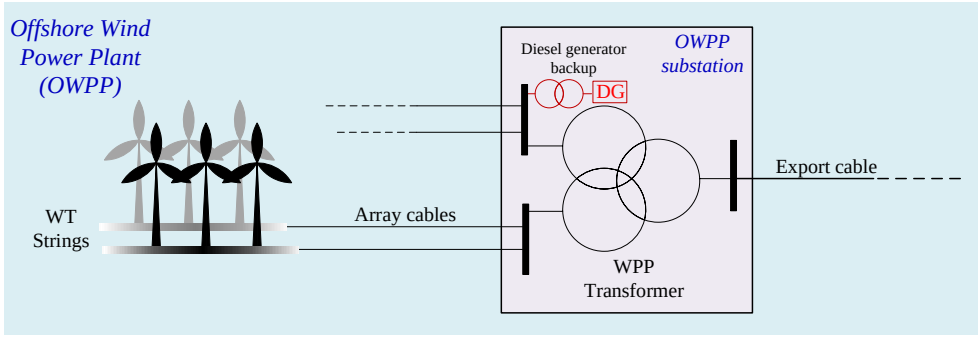
Generic Self-Energization Sequence

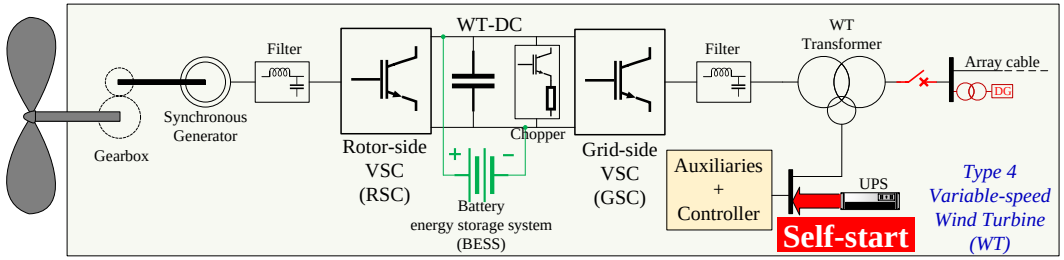


This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691714.

Generic Self-Energization Sequence

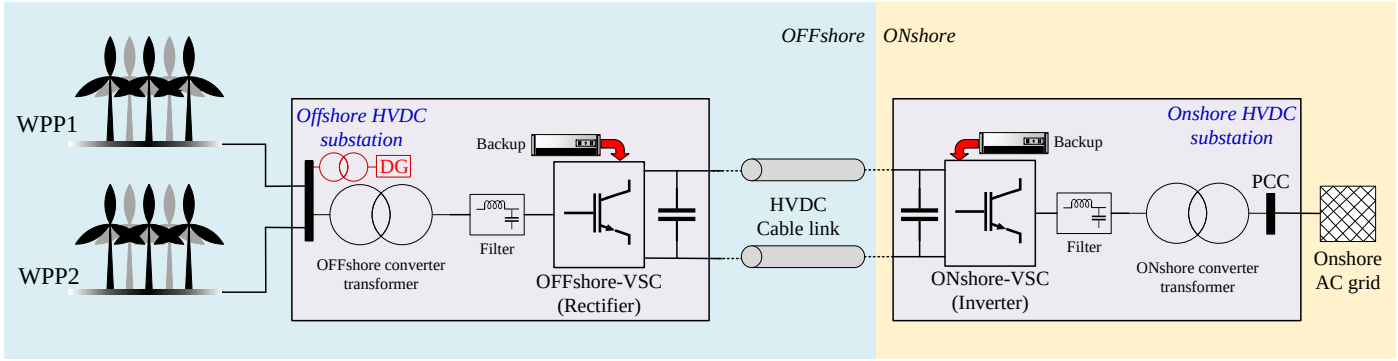


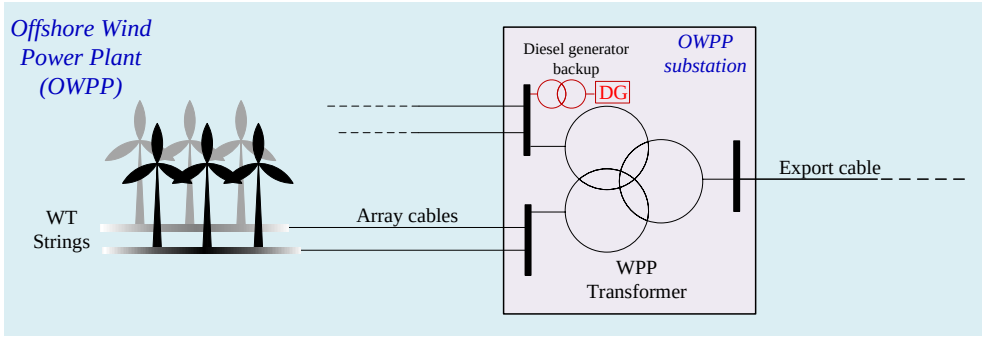


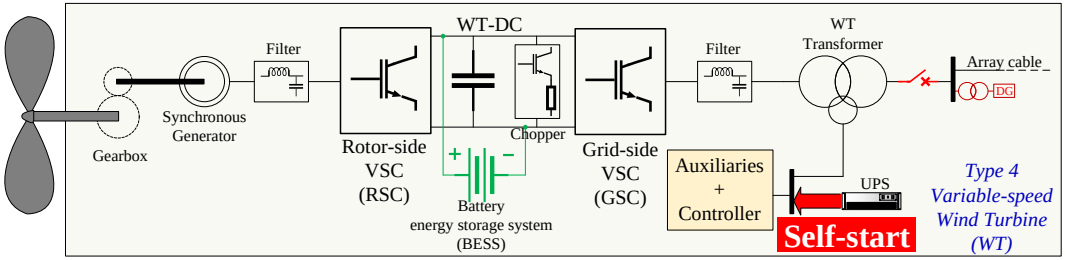


This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691714.

Generic Self-Energization Sequence





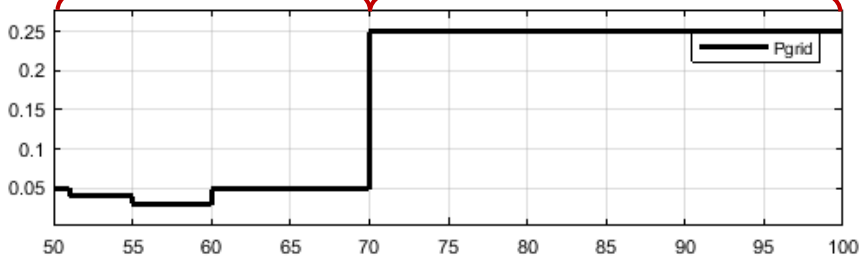


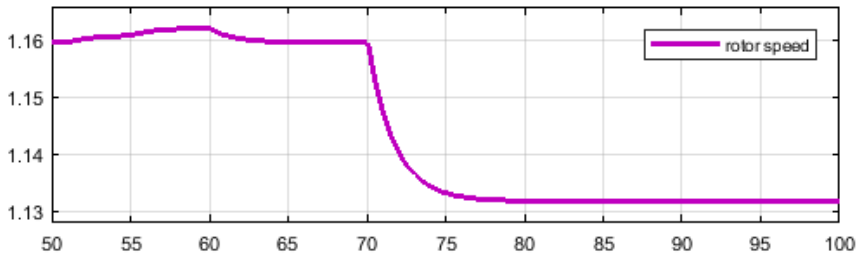
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691714.

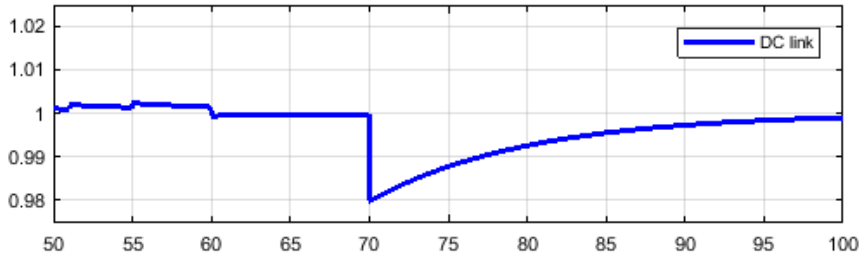
Supply of Auxiliaries and Step Load Changes
Wind turbine rotor side response

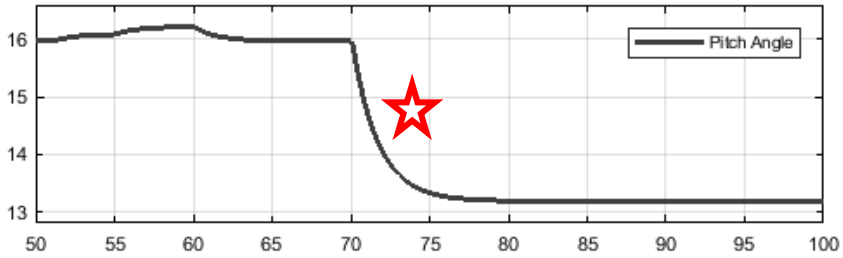
WT house-load (aux) 3-5%

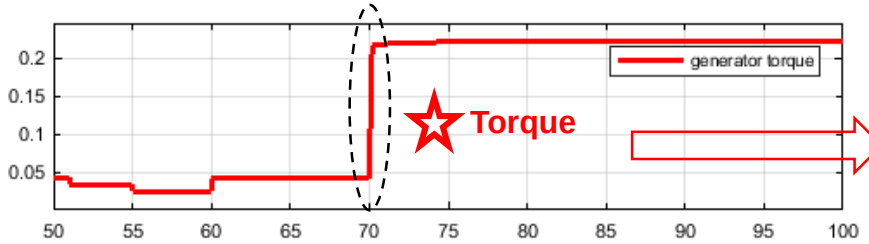
20% step P load











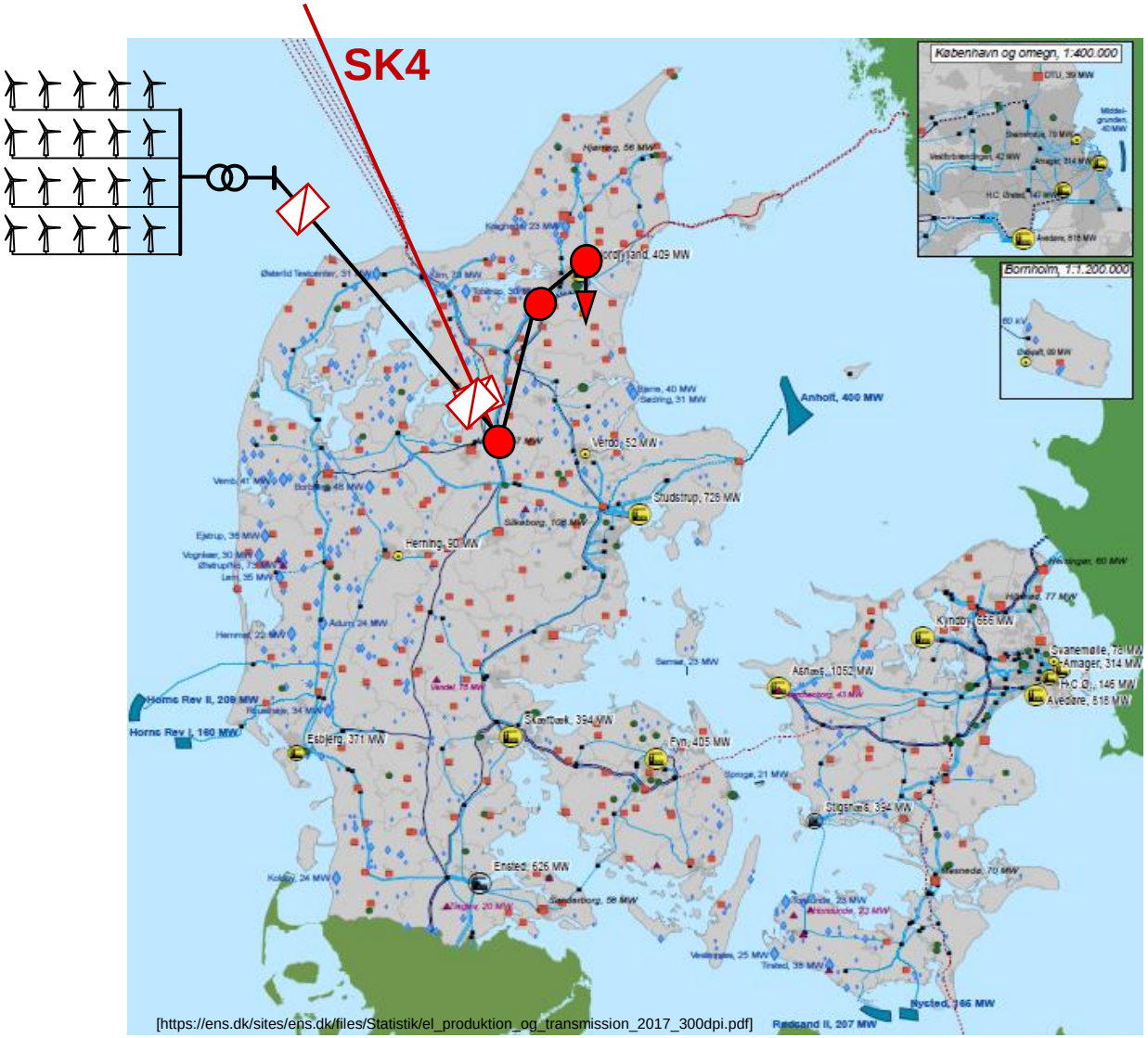
Torque

Impact on loads to be investigated!

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691714.

Ongoing: Black start simulation test on part of DK2

Energinet plans Black Start Simulation Test with Skagerrak 4 (SK4) HVDC interconnector (Norway-Denmark) outside PROMOTioN project



In PROMOTioN project:

Black Start Simulation Test with offshore WPP

To be energized;

- 3 buses
- Overheadline & underground cable
- Shunt reactor, transformer
- Step MW++ load
- Load stepwise changes
- Frequency & voltage setpoint changes
- Load disconnection

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691714.

APPENDIX

DISCLAIMER & PARTNERS

COPYRIGHT

PROJECT COORDINATOR

DNV GL Netherlands B.V.
Utrechtseweg 310, 6812 AR Arnhem, The Netherlands
Tel +31 26 3 56 9111
Web www.dnvgl.com/energy

CONTACT

PARTNERS

DNV GL Netherlands B.V., ABB AB, KU Leuven, KTH Royal Institute of Technology, EirGrid plc, SuperGrid Institute, Deutsche WindGuard GmbH, Mitsubishi Electric Europe B.V., Affärsverket Svenska kraftnät, Alstom Grid UK Ltd (Trading as GE Grid Solutions), University of Aberdeen, Réseau de Transport d'Électricité, Technische Universiteit Delft, Statoil ASA, TenneT TSO B.V., Stiftung OFFSHORE-WINDENERGIE, Siemens AG, Danmarks Tekniske Universitet, Rheinisch-Westfälische Technische Hochschule Aachen, Universitat Politècnica de València, SCiBreak AB, Forschungsgemeinschaft für. Elektrische Anlagen und Stromwirtschaft e.V., Ørsted Wind Power A/S, The Carbon Trust, Tractebel Engineering S.A., European University Institute, Iberdrola Renovables Energía, S.A., European Association of the Electricity Transmission & Distribution Equipment and Services Industry, University of Strathclyde, ADWEN Offshore, S.L., Prysmian, Rijksuniversiteit Groningen, MHI Vestas Offshore Wind AS, Energinet.dk, Scottish Hydro Electric Transmission plc, SCiBreak AB

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691714.