
DTU

Nicolaos A. Cutululis

Advanced Capabilities For Reliability Services From Wind Power

Agenda

- Wind power controllability
- Reliability services
- Contribution of wind power to restoration of power systems

Wind power control requirements

Grid Following	Grid Supporting	Grid Forming
P control Q Control	*f* support *V* support	*f* control *V* control
Need powered grid Operate mainly in strong grids (high SCR) Systems with high inertia	Need powered grid Connecting to weaker grids (low SCR) Systems with decreasing	No powered grid Islanded operation (SCR=0) Zero Inertia Shared control effort

Transformation of power systems

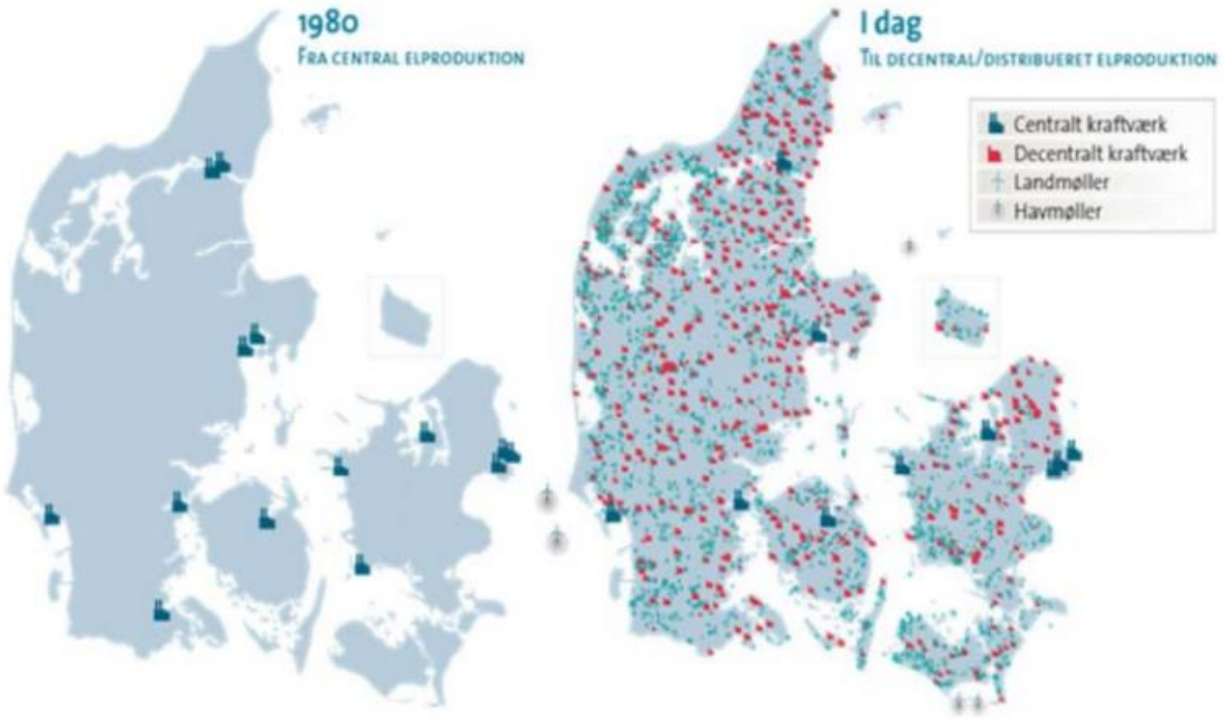


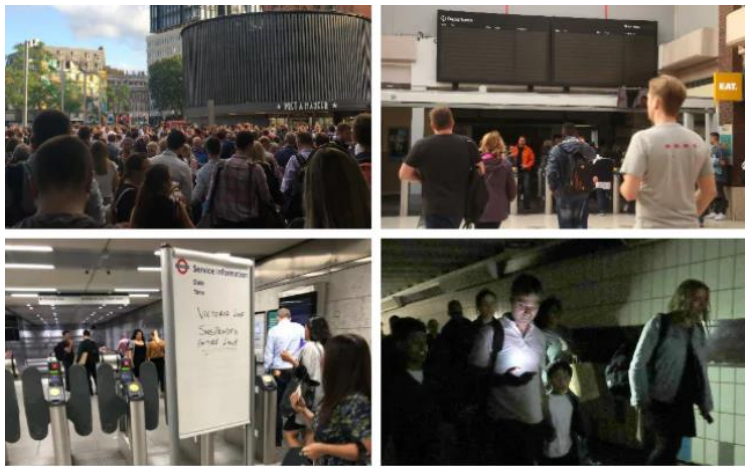
Figure 2-3: The Danish power system. Dominated by central power stations in the 1980s and today changed into a de-centralised power system with large amount of wind power

https://ens.dk/sites/ens.dk/files/Globalcooperation/integration_of_wind_energy_in_power_systems.pdf

Black-out

…rare events, especially major ones, however

August 2019, UK



September 2016, S. Australia

September 2019, Tenerife

Grid forming control of wind turbines

PROMOTioN
PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS

WP3 ◦ WTG – Converter Interaction

Main scope

- Cost reduction of offshore wind transmission by de-risking of Diode Rectifier Unit (DRU) offshore transmission concept
- Grid forming operation of wind turbines
- Advanced reliability services from wind power plants – black-start operation

Technical University of Denmark
UNIVERSITAT POLITÈCNICA DE VALÈNCIA
MHI VESTAS OFFSHORE WIND
University of Strathclyde
HITACHI
ABB
Ørsted
equinor
FGH
ENERGINET.DK
DNV·GL
RWTH AACHEN UNIVERSITY
SIEMENS

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

Grid forming control validation

Functional Requirements

Scenarios

HVAC, HVDC

Test cases

Validation based on simulations:

Generic Controllers
Vendor Specific Controllers

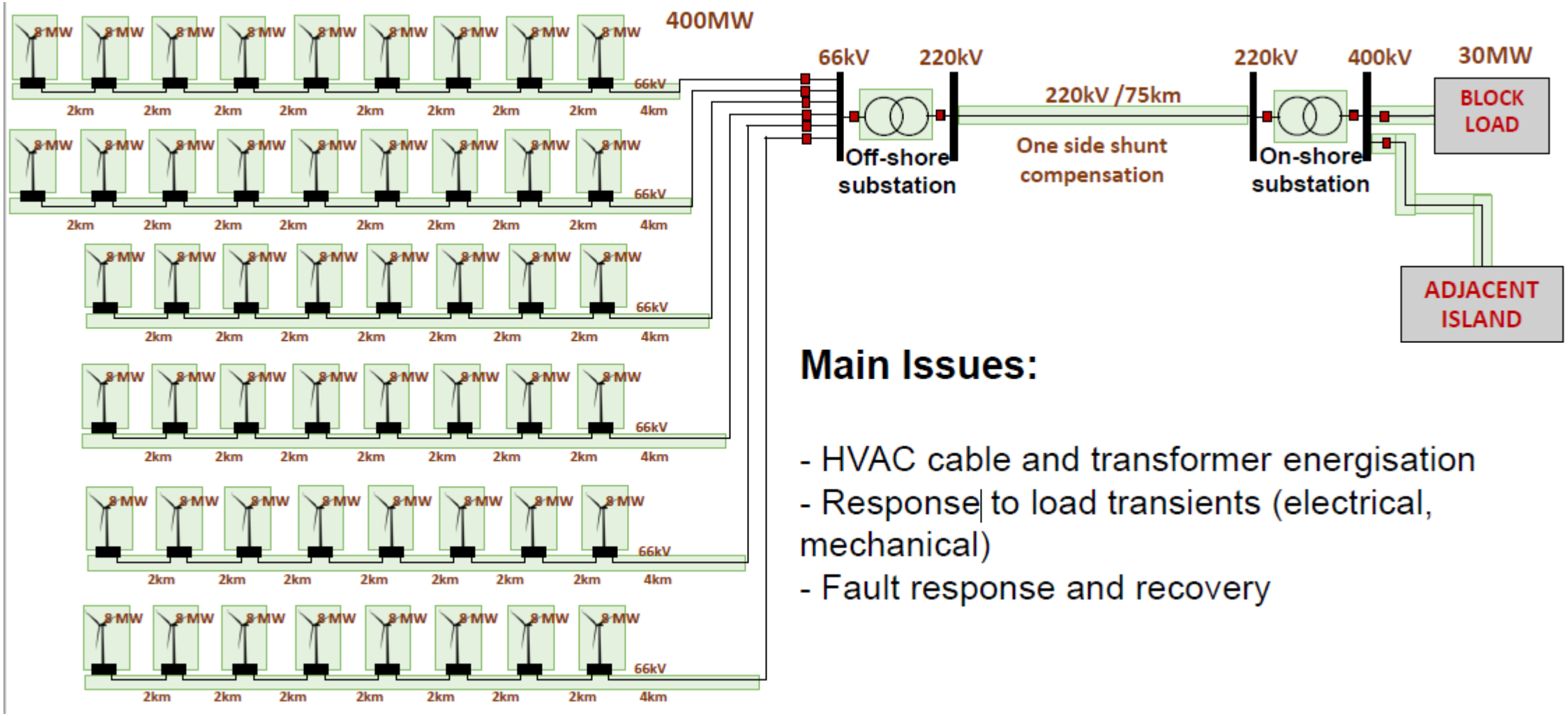
Voltage control capability, frequency control capability, fault behaviour, block load, harmonics, etc.

Mainly adapted from NGET, Elia, but some of them left loosely defined on purpose to find limits of grid forming technical capability

Grid Forming Wind turbines for black start operation should contribute actively to keep voltage/frequency between limits.

Grid Codes allow (Grid Following) Wind Turbines to trip if voltage/frequency are outside certain limits.

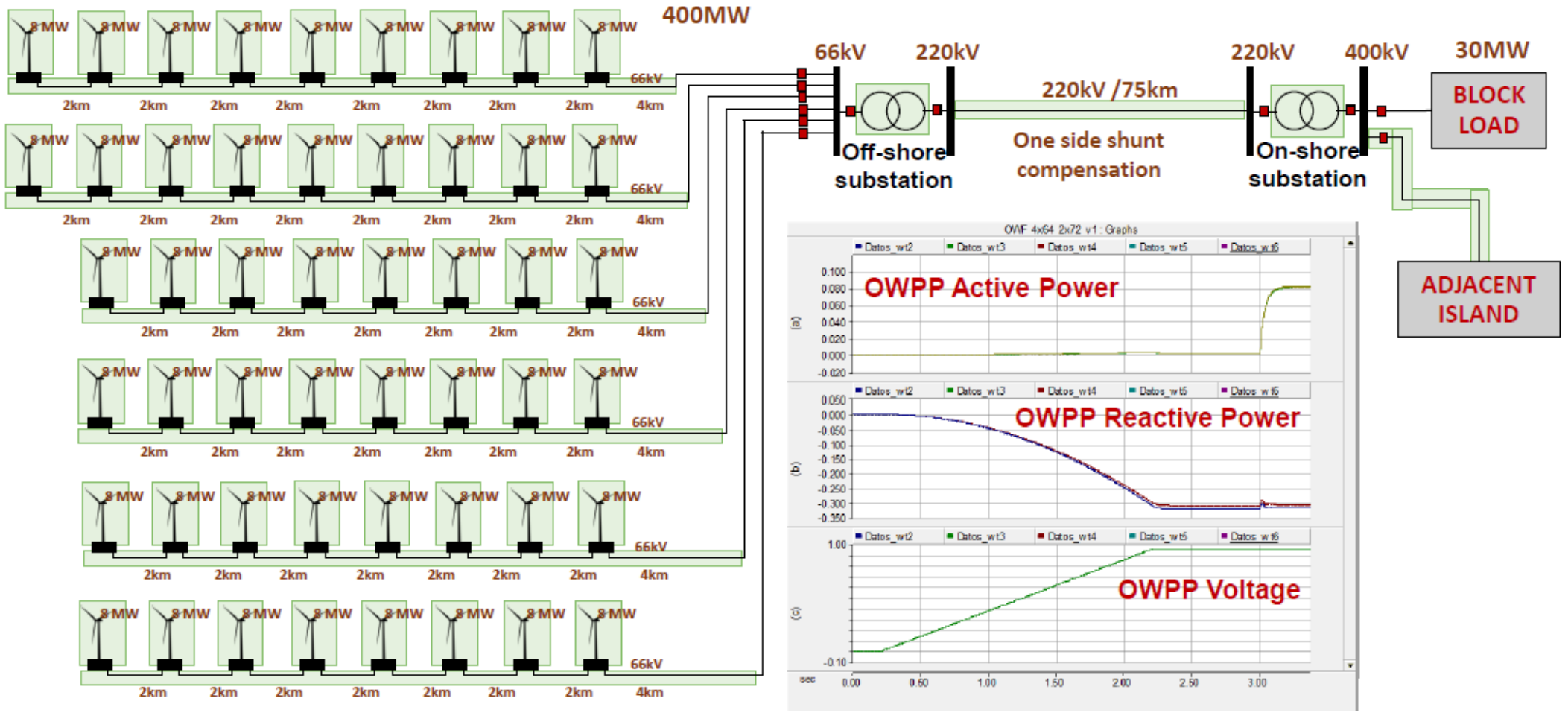
HVAC connected OWPP – hard switching



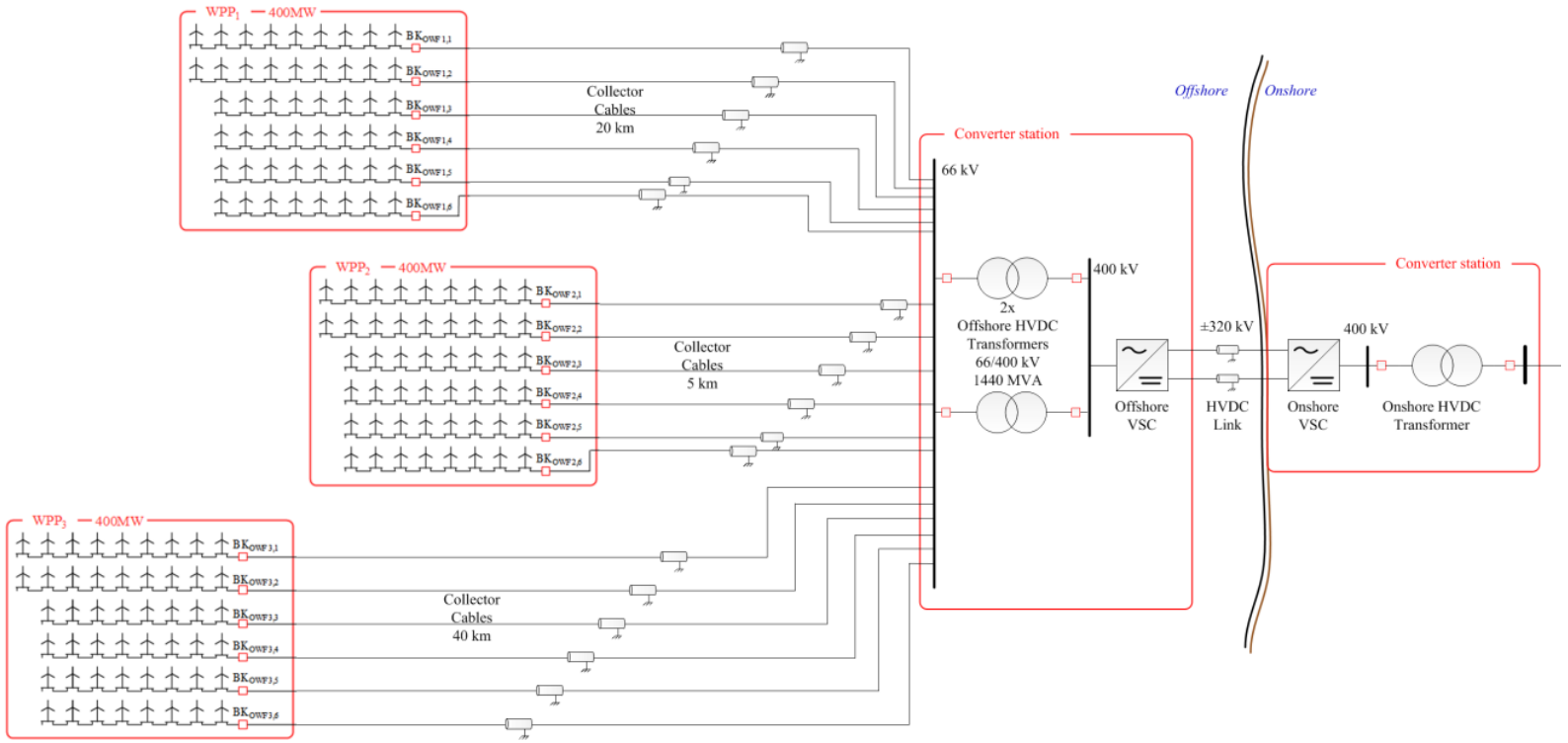
Main Issues:

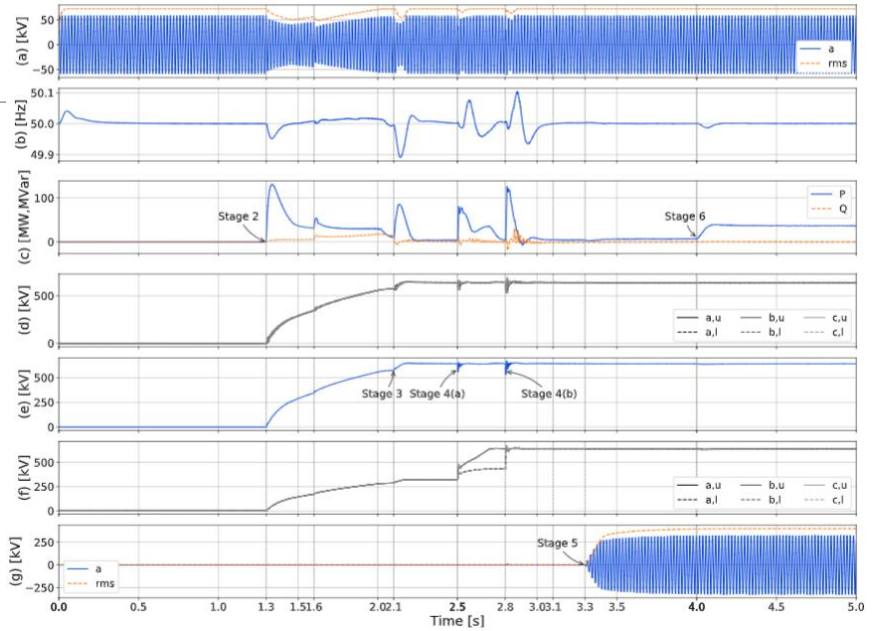
- HVAC cable and transformer energisation
- Response to load transients (electrical, mechanical)
- Fault response and recovery

HVAC connected OWPP – soft start



HVDC connected OWPP





Lessons learnt

- **With adequate requirements, Black Start operations can be carried out with partial or small modification to existing WTG converters.** (Although control is very different -> new certification process).
- **Local WTG storage might be required.**
- **Sequential start might lead to overvoltage/overcurrent** due to inrush currents, ferromagnetic oscillations and takes a relatively long time. Can be done with careful studies and tests (POW might be required).
- **Soft start leads to much faster energization time and minimises inrush current and oscillations.**
- **Fault recovery is very important with a large number of grid forming WTGs/WPPs.**
- **Grid forming control has to be robust to:**
  - Large changes in grid resonant peaks
  - Interaction with other converters/generators in the same area.

Thank you! Questions?

www.promotion-offshore.net

North Sea Grid for the European Green Deal

How to unlock Europe's Offshore Wind potential – a deployment plan for a meshed HVDC grid

Pre-Conference Sessions

08/24/20 – 09/18/20

24 AUG 2:00 – 5:30 PM	PROMOTioN @ CIGRE Join the PROMOTioN Team on Channel 4 at the CIGRE 2020

Breakout Sessions

Pre-recorded presentations available Mondays each week, live Q&As with our experts every Friday

31 AUG – 04 SEP	Offshore HVDC Grid Technology Live Q&A: Friday, 09/04/20, 10:00 AM – 12:00 PM
07 SEP – 11 SEP	HVDC Technology qualification Live Q&A: Friday, 09/11/20, 10:00 AM – 12:00 PM
	Legal, Regulatory & Economic Aspects Live Q&A: Friday, 09/11/20, 1:00 PM – 3:00 PM
14 SEP – 18 SEP	Meshed Offshore Grid Planning Live Q&A: Friday, 09/18/20, 10:00 AM – 12:00 PM

Virtual Conference Agenda

Live Event, 09/21/20

10:00 - 10:20 AM	Keynotes & Welcome Address
10:20 - 10:45 AM	**Introduction to PROMOTioN**: How to approach the creation of a European offshore grid
10:45 - 11:00 AM	Feedback Round
11:00 AM – 12:00 PM	Reports from the Breakout Sessions
12:00 - 12:30 PM	**Lessons from PROMOTioN**: Key steps towards a meshed HVDC offshore grid
12:30 - 1:00 PM	Lunch Break
1:00 - 2:30 PM	**Live Panel Discussion: Fitting the puzzle pieces**
2:30 – 2:45 PM	Feedback round
2:45 – 3:00 PM	Wrap up & Concluding remarks

PROMOTioN
PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS

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

Nicolaos A. Cutululis

niac@dtu.dk; +45 2132 4965