SOFIA and Dogger Bank C OWF interaction study: Overview and Prospects for Real-Time Interaction Studies

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RTE international

HUGM RTDS USER'S GROUP MEETING

2024 EUROPE USER'S GROUP MEETING

DELFT, NETHERLANDS

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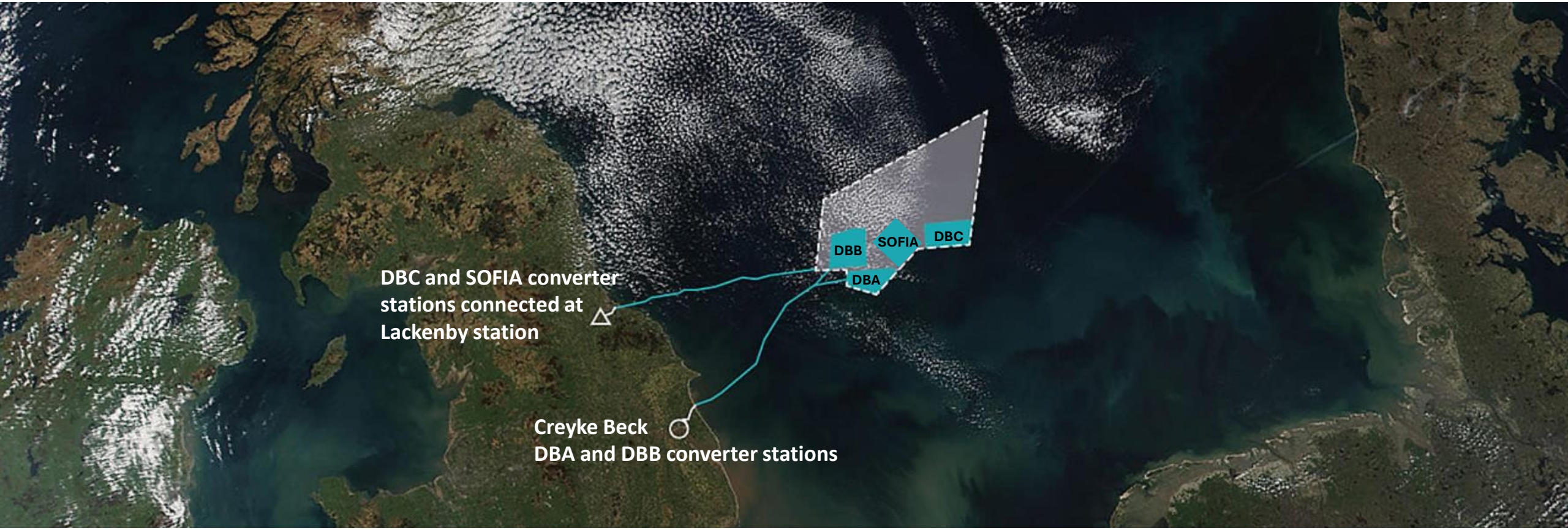
AMETEK

SOFIA AND DBC OFFSHORE WIND PROJECTS



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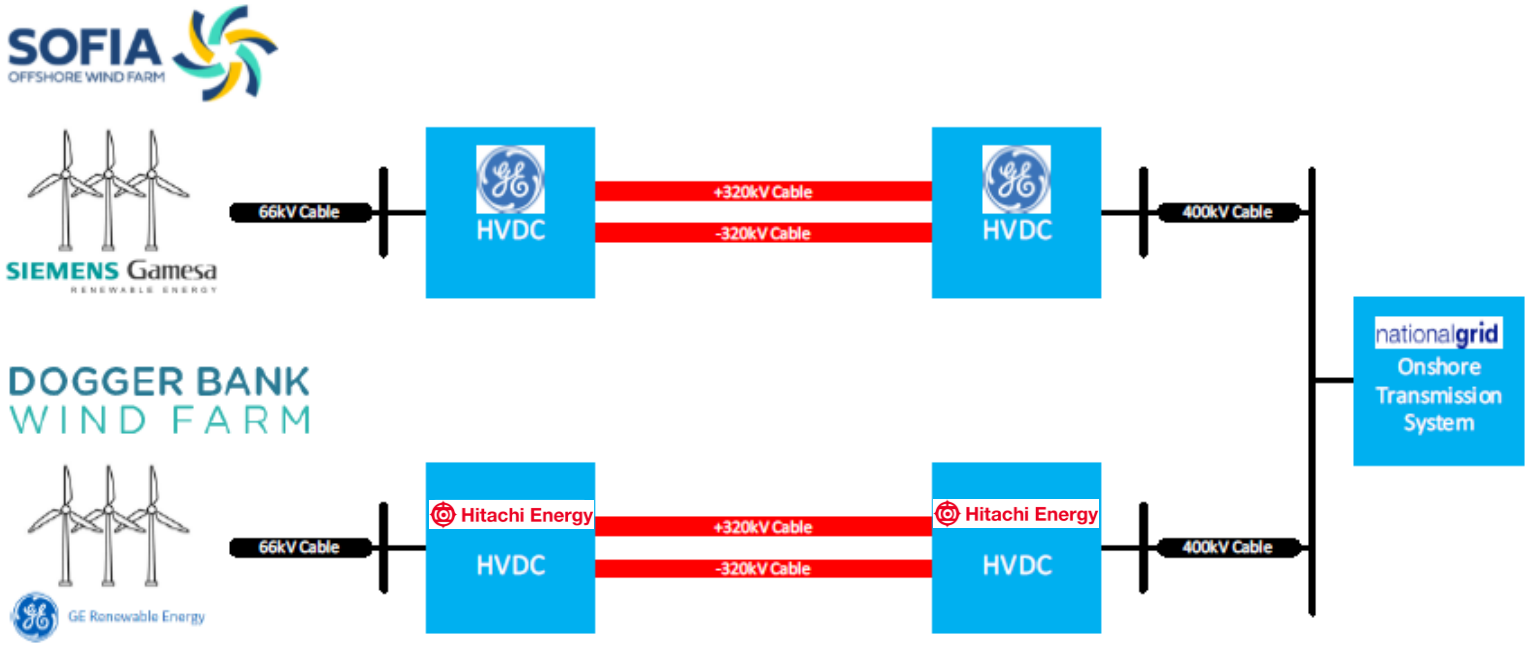


PROJECT OVERVIEW

Objective of the project

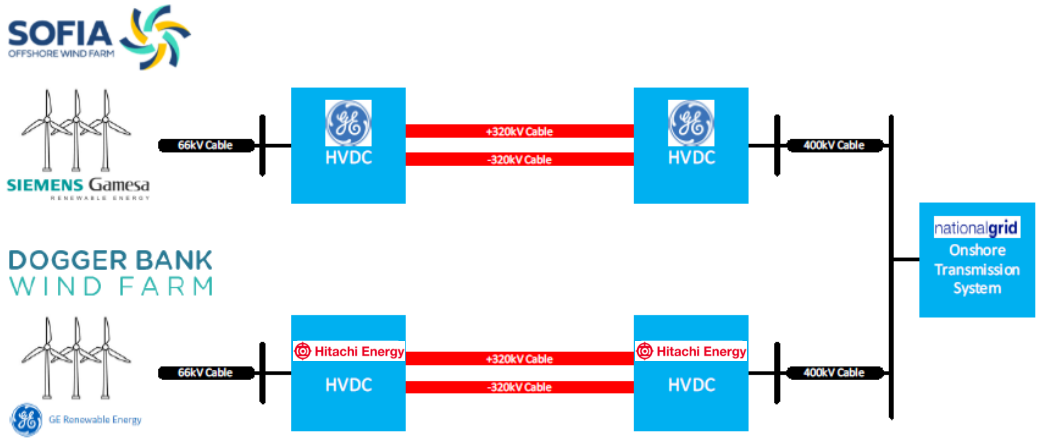
Identification and mitigation of possible adverse interactions between SOFIA and DBC HVDC

Tools

Use of EMT simulation with models (**WP1**) and replicas (**WP2**)

RTEi's methodology

Independent 3rd Party
Coordination with all Stakeholders
Assuring IP protection
Definition of test matrix
Performing simulations
Sharing results
Contribute to mitigation solutions



FOCUS ON WP1

Main activities

EMT model specifications

Test of individual models

Analysis and discussions

Definition of test cases

Merging models and automation

Data accessibility (models and results)

Running simulations

Liquid cooled CPU - AMD Ryzen Threadripper Pro
128 parallel simulations
20hours to run ~500 cases

FOCUS ON WP1

EMT model specification for HVDC and OWF systems

Data accessibility

HV electrical equipment	**Fully accessible and detailed representation**
Control and Protection system	**Can be black-boxed. However,** • **Certain control variables in station and upper-level controls may be accessible for monitoring** • **High-level control system description** • **Protection system should be available in the models**
Model parameters	**Minimum list of tunable parameters**

FOCUS ON WP1

EMT model specification for HVDC and OWF systems

Functional requirements

Main functions

- All relevant C&P functions are included
- Most relevant AC and DC protections are included
- Most relevant control strategies are included
- Vendors specify the C&P functions not included (to be validated by Clients)

Signal availability

- Define a minimum list of available signals

Modeling

- Level of details for HVDC, OWF, and offshore grid representation
- Consensus among all stakeholders
- Adequate for project-specifics
- Solution should be implemented to speed up the start-up sequence

FOCUS ON WP1

EMT model specification for HVDC and OWF systems

Model delivery

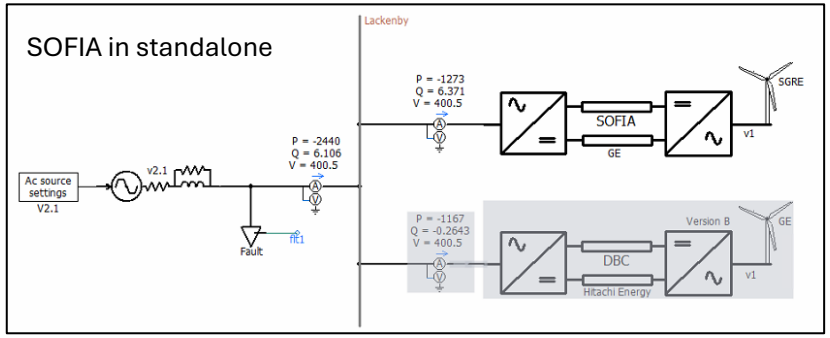
EMT platform

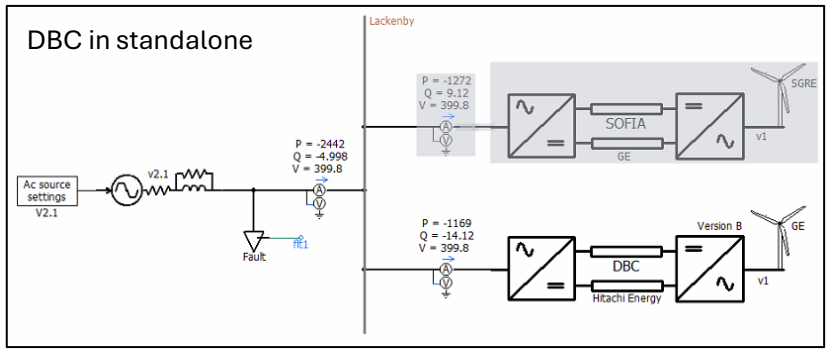
- Compatible with PSCAD version 4.6.3
- Compatible with Visual Fortran Compiler XE 18 or later
- All required compiled files (*.lib, *.dll)
- Model documentation is available

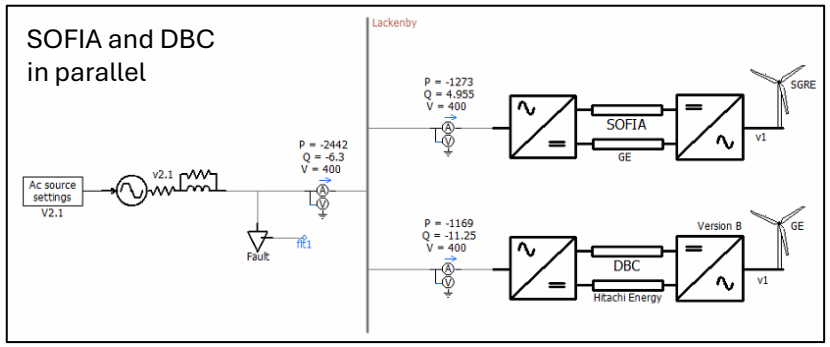
Non-compliance list

A non-compliance list is drafted by RTEi after model delivery

INTERACTION STUDY





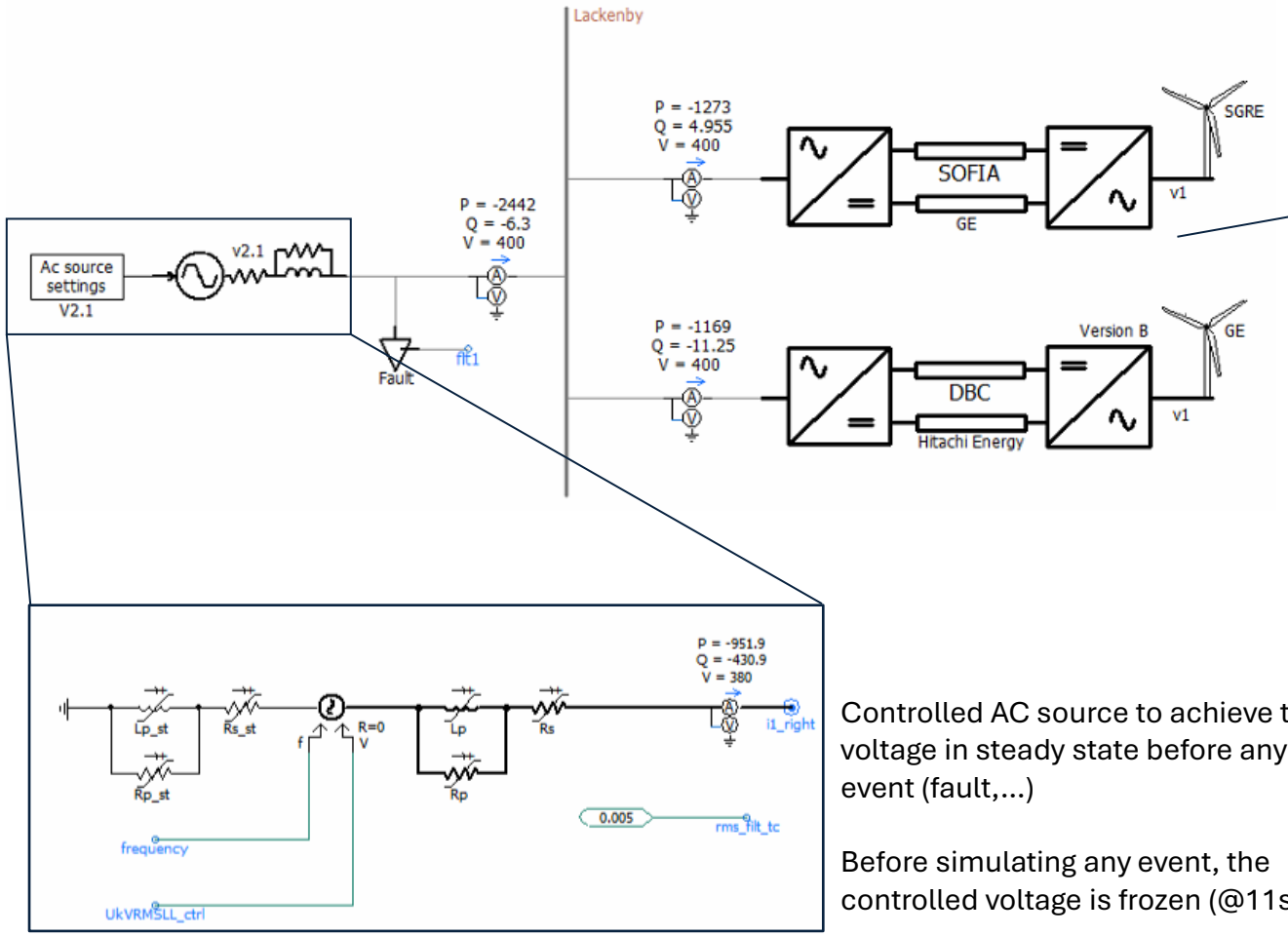


Objective of the study: assessment of possible adverse interactions between SOFIA and DBC.

Methodology applied with offline models and HiL setup:

- Define test matrix with all relevant scenario for parallel operation
- Integrate models/replicas in a single circuit
- Run simulations in parallel and in standalone
- Compare performances in parallel and in standalone operation
- Generate reports and share results

PSCAD CIRCUIT FOR THE INTERACTION STUDY



Entire model including both AC onshore cables, filter...

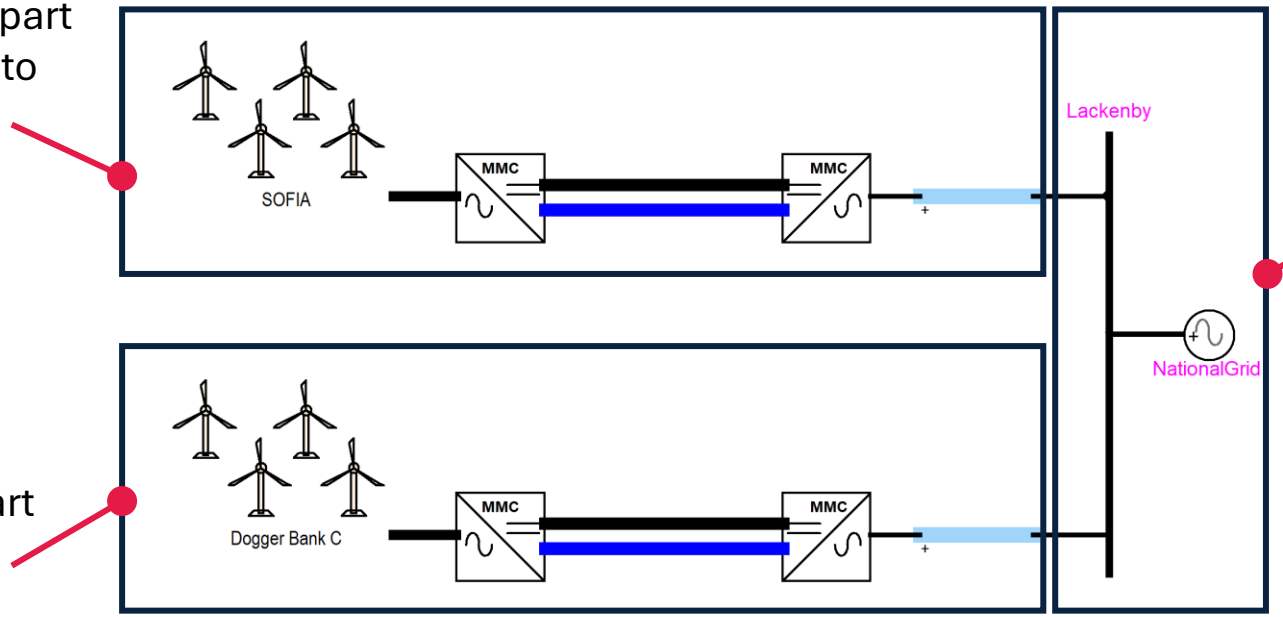
No parallel computing to facilitate automation process

Controlled AC source to achieve target voltage in steady state before any event (fault,...)

Before simulating any event, the controlled voltage is frozen (@11s)

INTERACTION STUDY METHODOLOGY

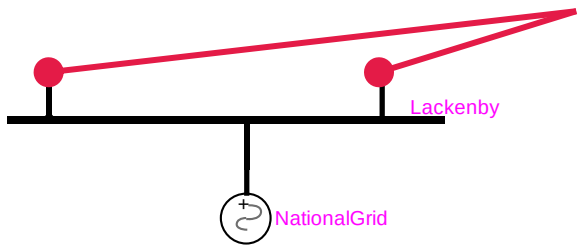
All results generated by this part of the model are accessible to GE + SOFIA only



All results generated by this part of the model are accessible to all parties

All results generated by this part of the model are accessible to HE + DBC only

Results are provided in 2 formats:
- PDF reports with simulated waveforms (by default)
- COMTRADE format (When further analysis is required)



Accessible to all parties:
- Instantaneous voltage and current waveforms
- P and Q calculated by each HVDC OEM

INTERACTION STUDY METHODOLOGY

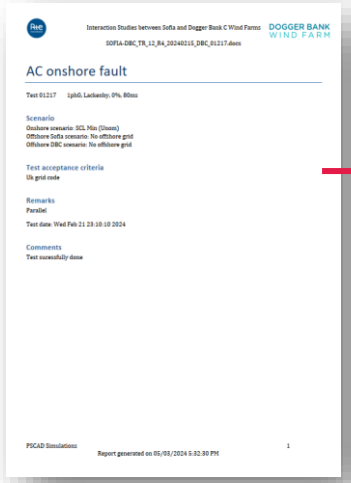
Test reports shared with both projects

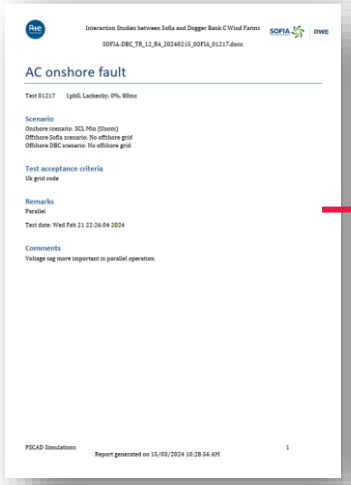
DBC_reports

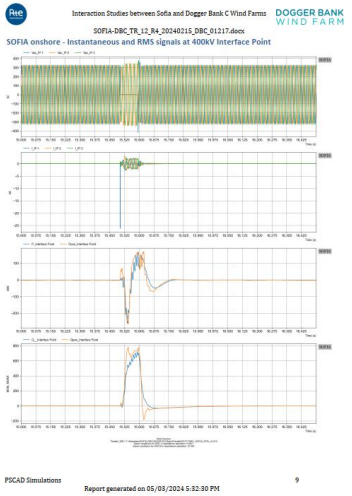
Parallel_DBC_reports

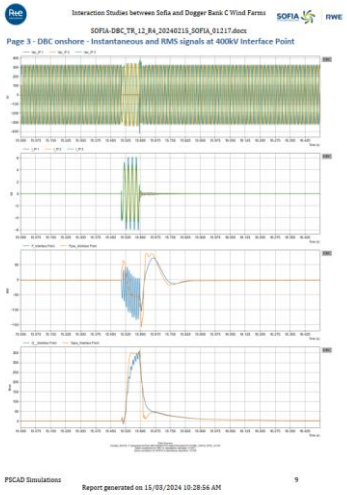
Parallel_SOFIA_reports

SOFIA_reports









INTERACTION STUDY METHODOLOGY

Test matrix definition

AC onshore fault

AC offshore fault

Start-up / Shutdown sequences

Transformer energization onshore / offshore

Variations in OWF power production

HVDC/WTG/WFC setpoint changes

Harmonic impedance assessment for the onshore converters

DC fault, trip of 1 HVDC

System performance for onshore frequency events

System performance for onshore voltage deviations

Inadvertent operation of onshore AC breakers

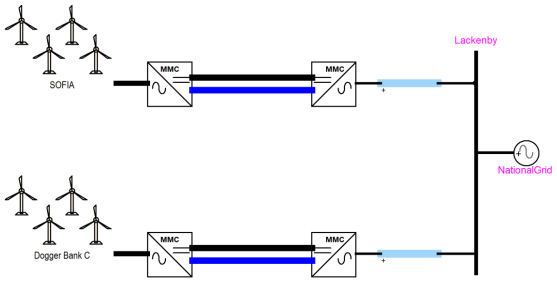
Control stability screening

INTERACTION STUDY METHODOLOGY

Iterative evaluation (WP1)

- Preliminary tests to avoid full study repetition
- Iteration study finally completed in Feb 2024

Model integration (RTEi)

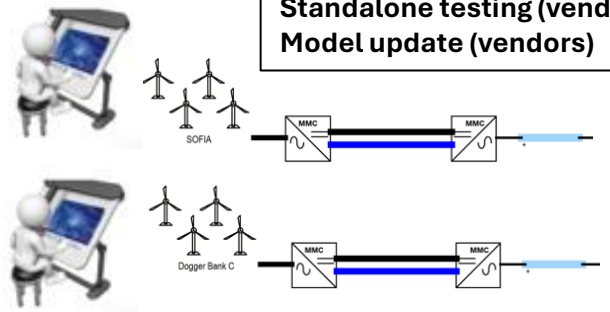


Testing (RTEi)

3 times

Report generation (RTEi)
Result analysis (RTEi and vendors)
Solution proposal (RTEi and vendors)

Solution implementation (vendors)
Standalone testing (vendors)
Model update (vendors)



FOCUS ON WP1

Main outcomes

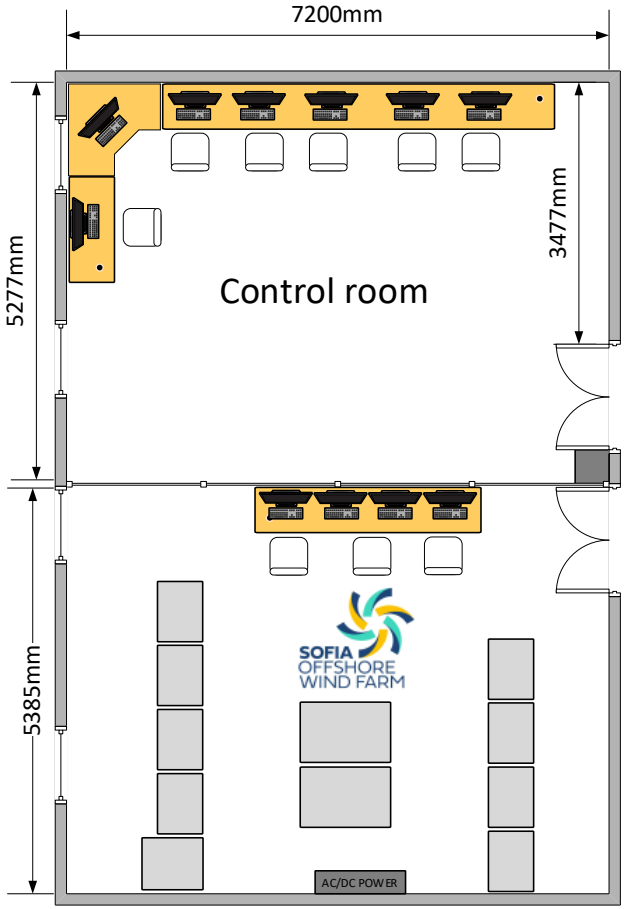
- Models provided by HVDC OEMs required more adaptations and corrections than expected to fulfil the requirements
- Identification of issues in standalone operation with the preliminary tests conducted on each HVDC scheme
- Options to optimize parallel operation have been identified
- In case of PSCAD model update: partial repetition of test cases

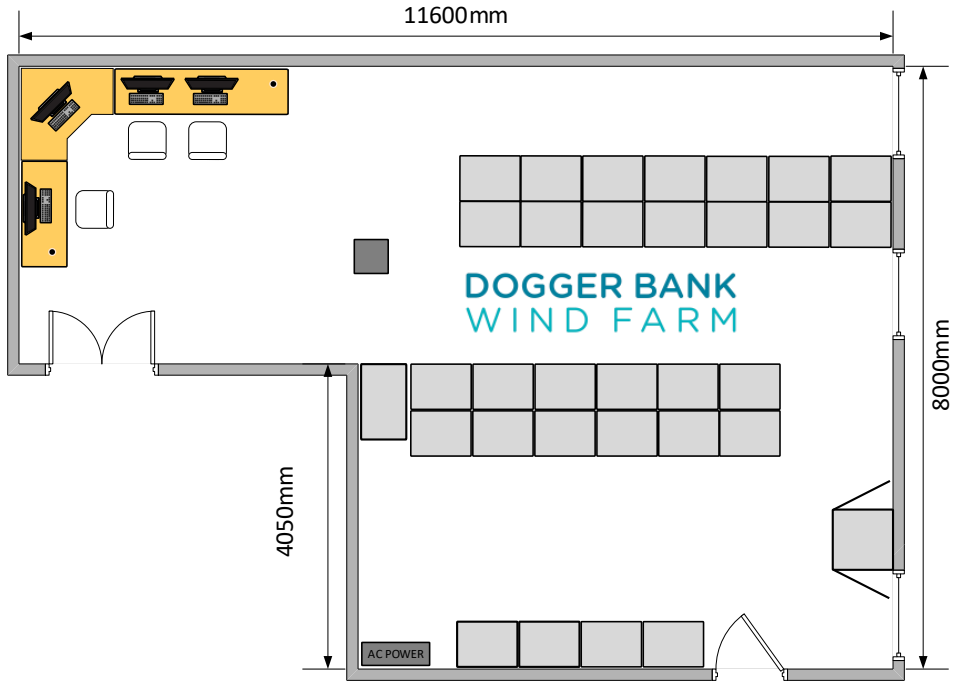
FOCUS ON WP2

Main activities

- Replicas specifications
- Procurement of the RTS
- FAT participation
- Model adaptation (OWF + HVDC merging)
- Update of the test matrix
- Preparation of lab facility
- Testing individual replica (PSCAD benchmark)
- Running simulations
- Analysis and dicussions

REAL-TIME LAB LAYOUT





REAL-TIME LAB LAYOUT

DBC replica delivery on April 12th, 2024 at RTEi lab

DBC replica in RTEi lab

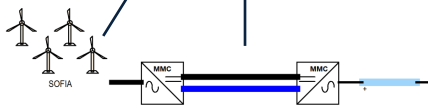
SYSTEM OVERVIEW

GE HVDC C&P replica

Real time simulation scope

I/O interfaces

Operator room



HE HVDC C&P replica

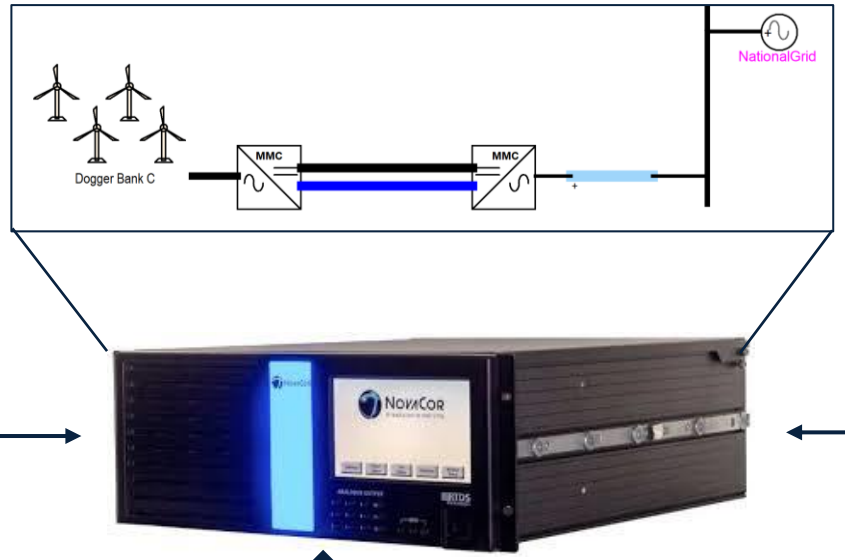
Hitachi Energy

I/O interfaces

WP2 – ONGOING ACTIVITIES

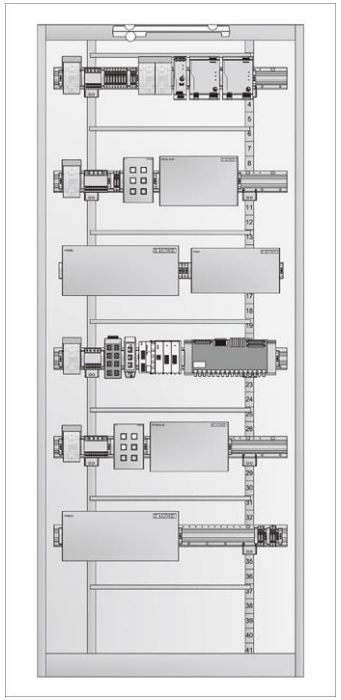
WTG DBC: Blackbox model to be executed in GTSOC board

C&P code including WTC, CC, WFC (delivered by GE)



RSCAD model delivered

- By GE for WTG electrical equipment
- By Hitachi Energy for the HVDC electrical equipment



DBC HVDC C&P replica

CONCLUSION

Interaction study of 2 HVDC links

- Test cases have been agreed with all stakeholders
- EMT offline models have been delivered by HVDC and Wind OEM as expected
- Several iterations have performed in standalone operation before starting interaction study
- DBC replica was delivered on April 12th, 2024
- Replicas are used to:
  - Perform test cases not simulated with offline models
  - Benchmark against offline simulation (Quality control)