

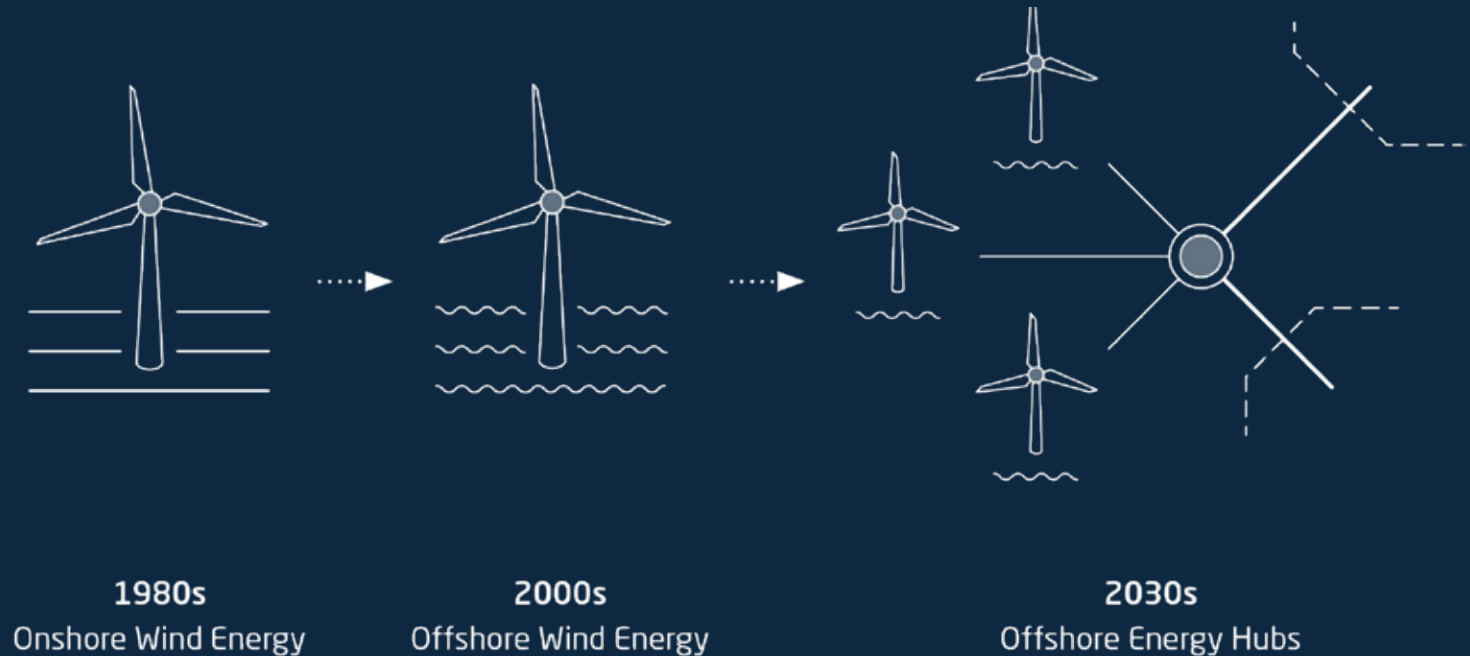
RTDS modeling of the Bornholm Energy Island

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What is an Energy Island/Hub?

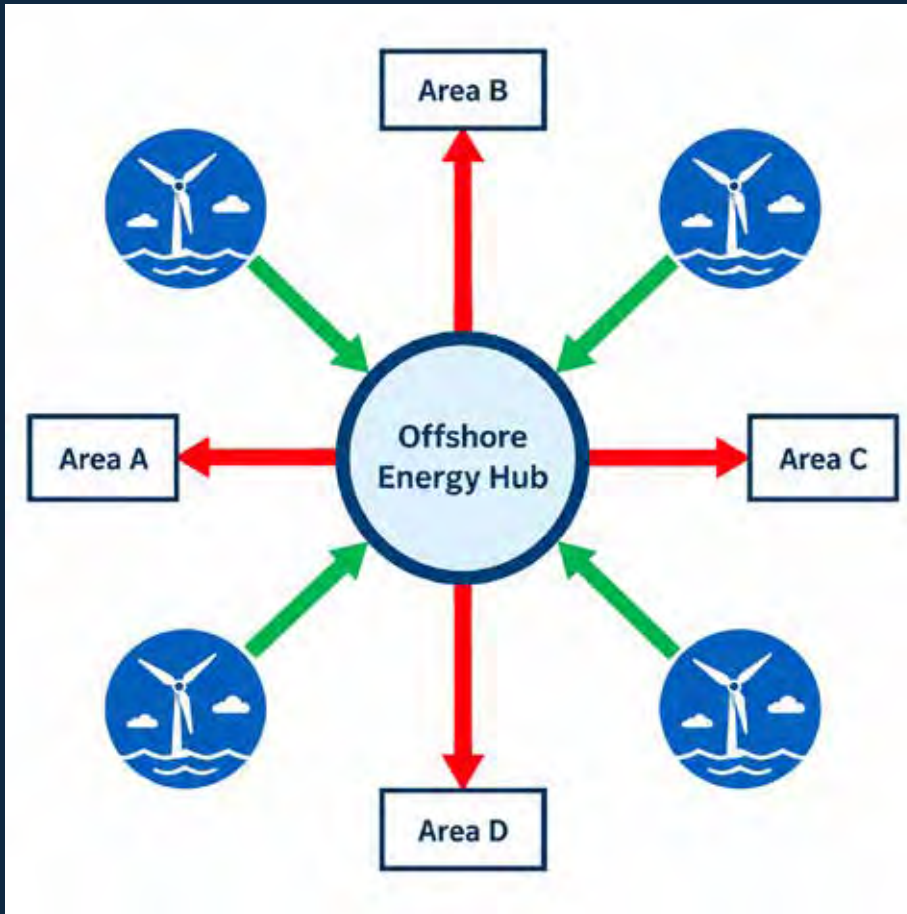
- Energy Islands are hubs connecting multiple offshore wind power plants to the power grid using multiple HVDC converters from different vendors. They may also host storage and power-to-gas conversion units.



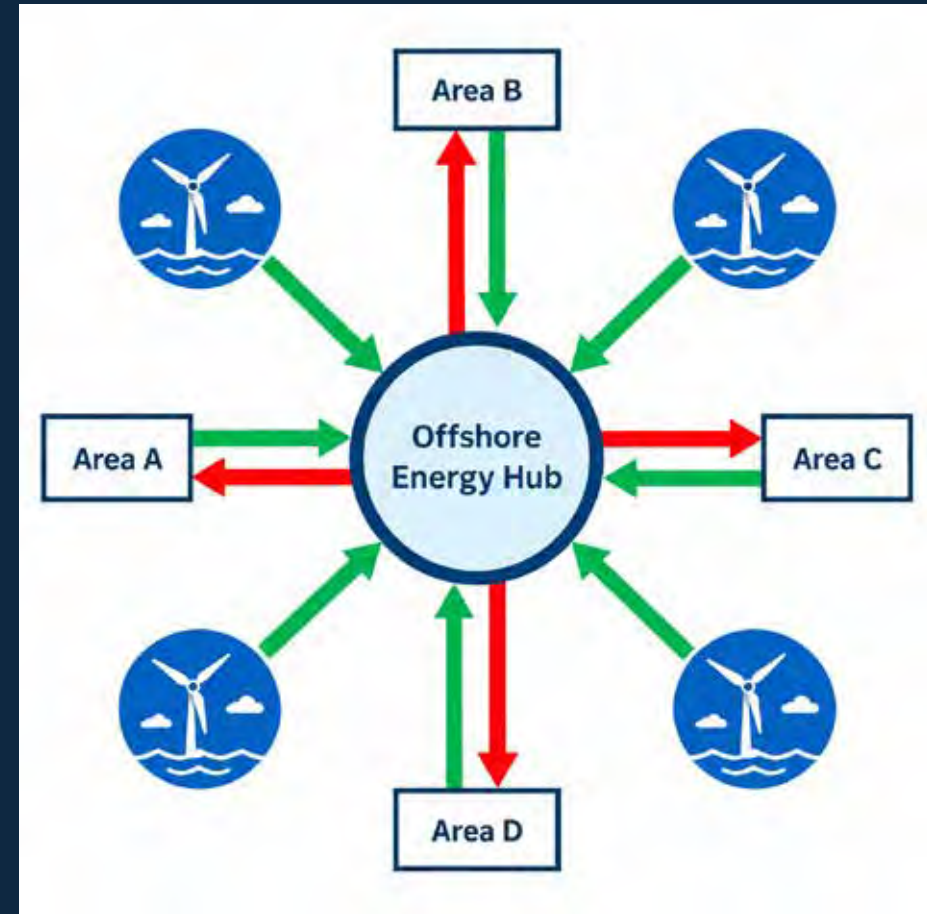
Source: Denmark as the Energy Island Pioneer

What is an Energy Island/Hub?

Wind Export



Interarea Power Transfer



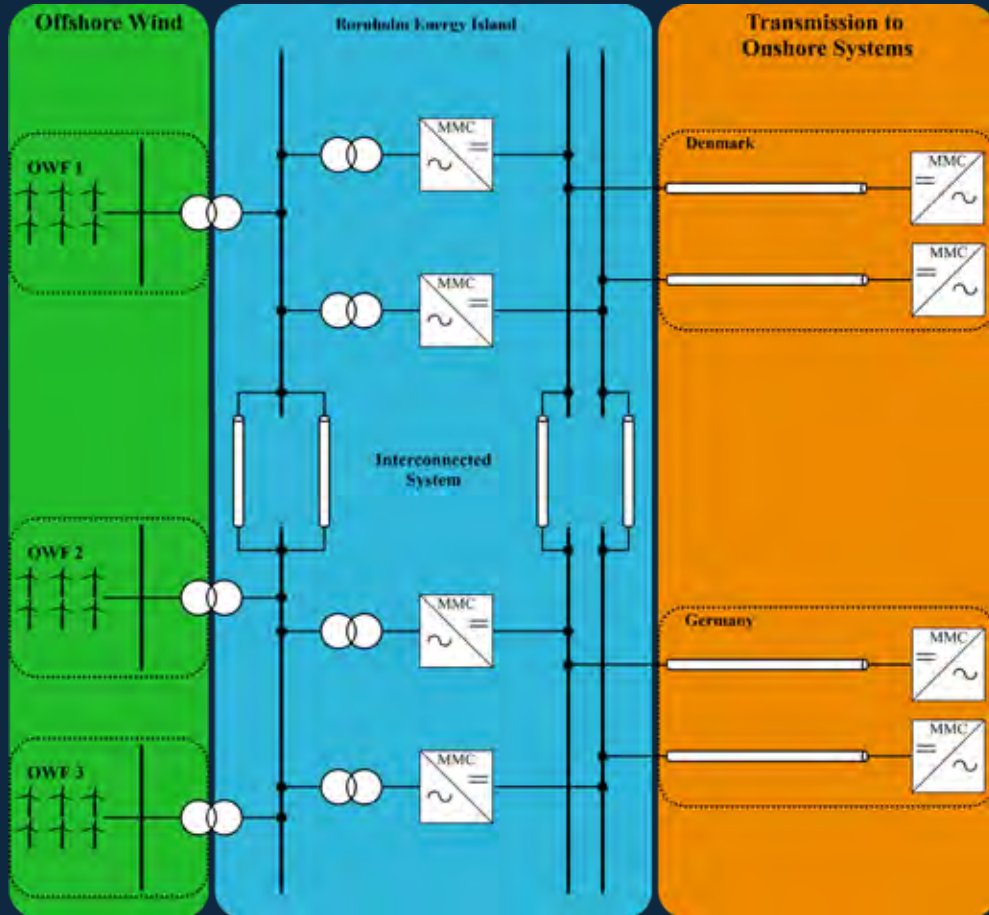
The Bornholm Energy Island

- One of Denmark's largest and most important infrastructure project
- More than doubles the installed offshore wind capacity in Denmark
- Will serve as a model for future energy hubs in the north sea



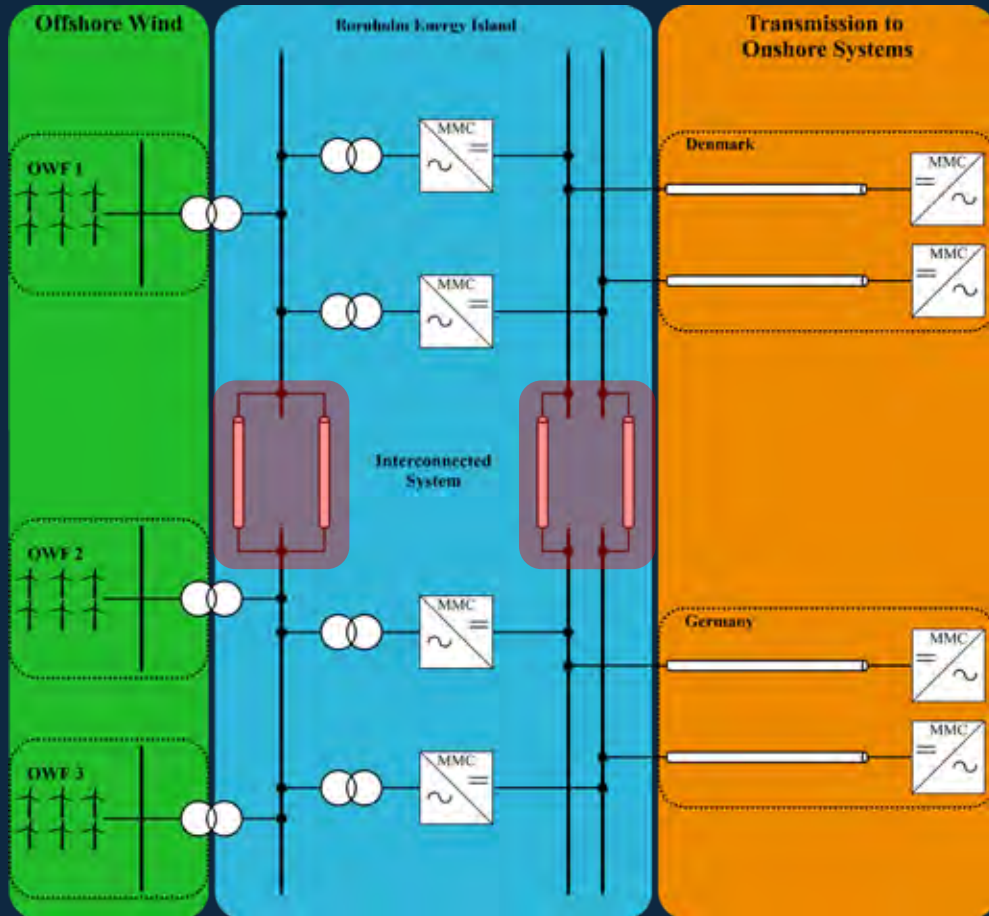
Source: <https://www.energinet.dk/bornholminterconnector/>

The Energy Hub topology



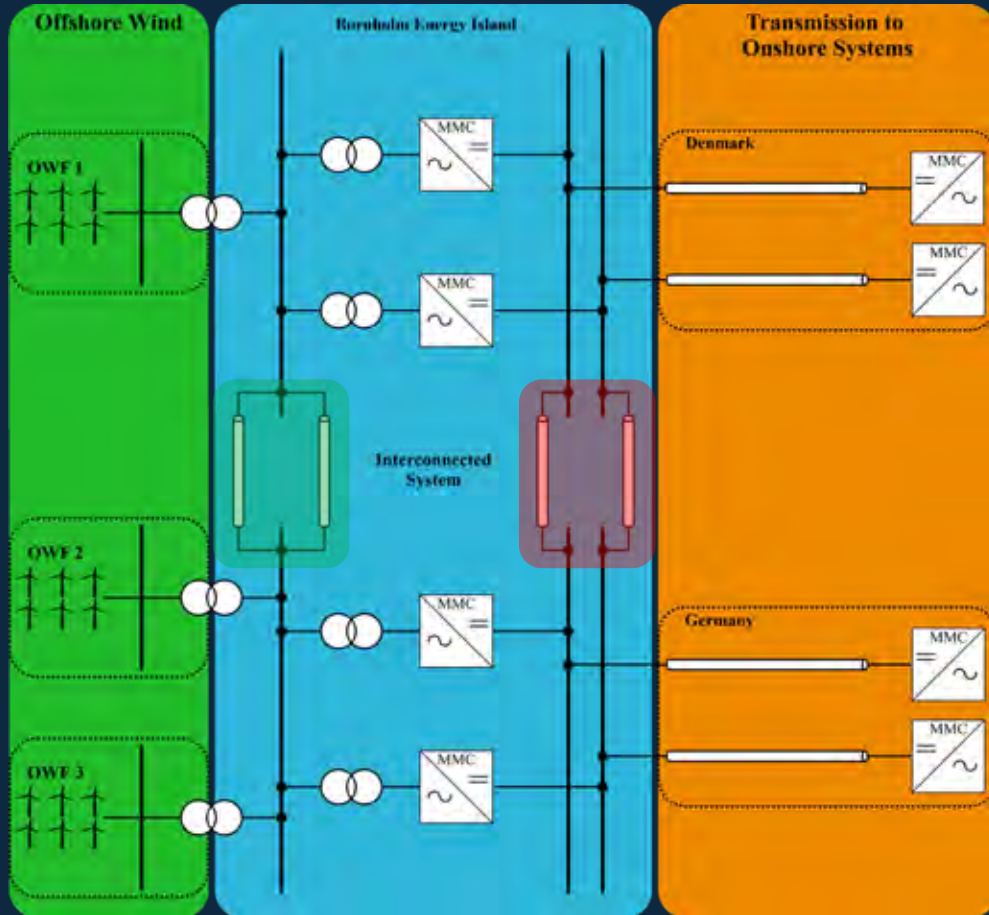
- 3 GW of Offshore Wind
- 1.2 GW Interconnection to Denmark
- 2 GW Interconnection to Germany
- Hybrid Hub Topology – AC or DC

The Energy Hub topology – Split



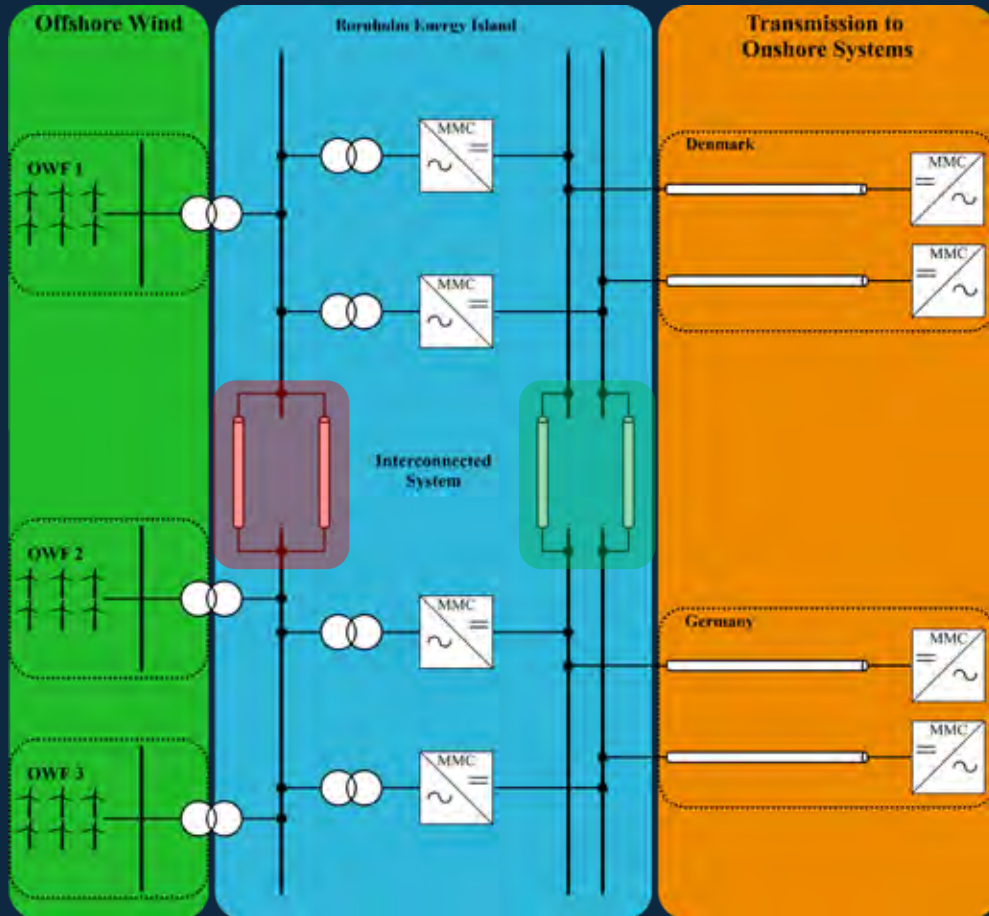
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The Energy Hub topology – AC hub



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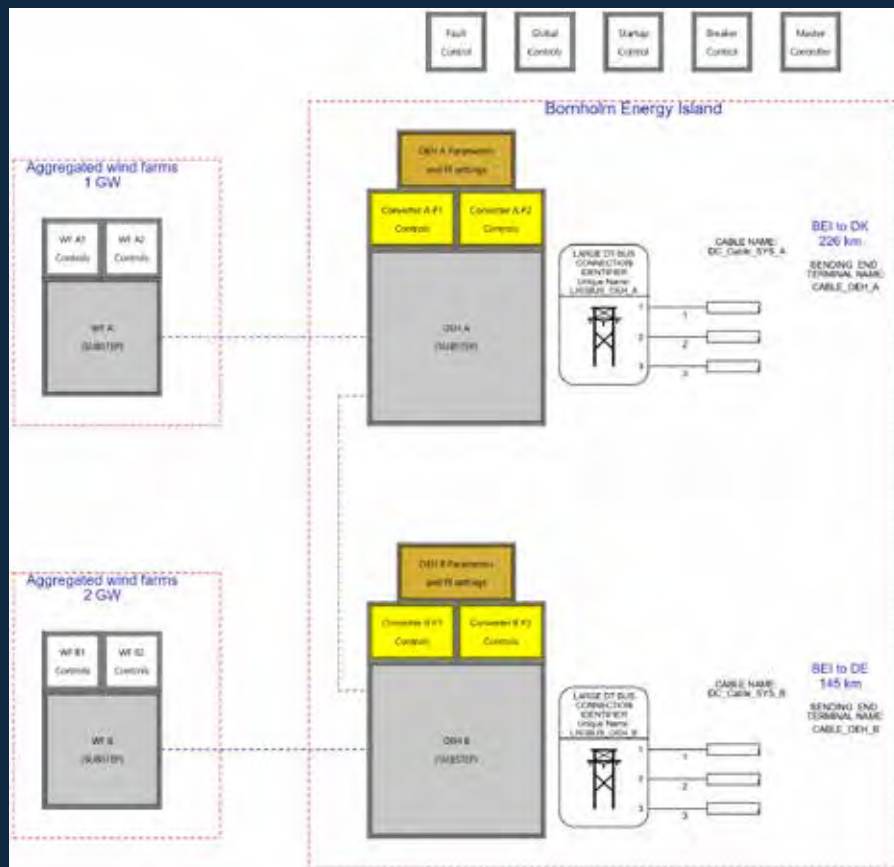
The Energy Hub topology – DC hub



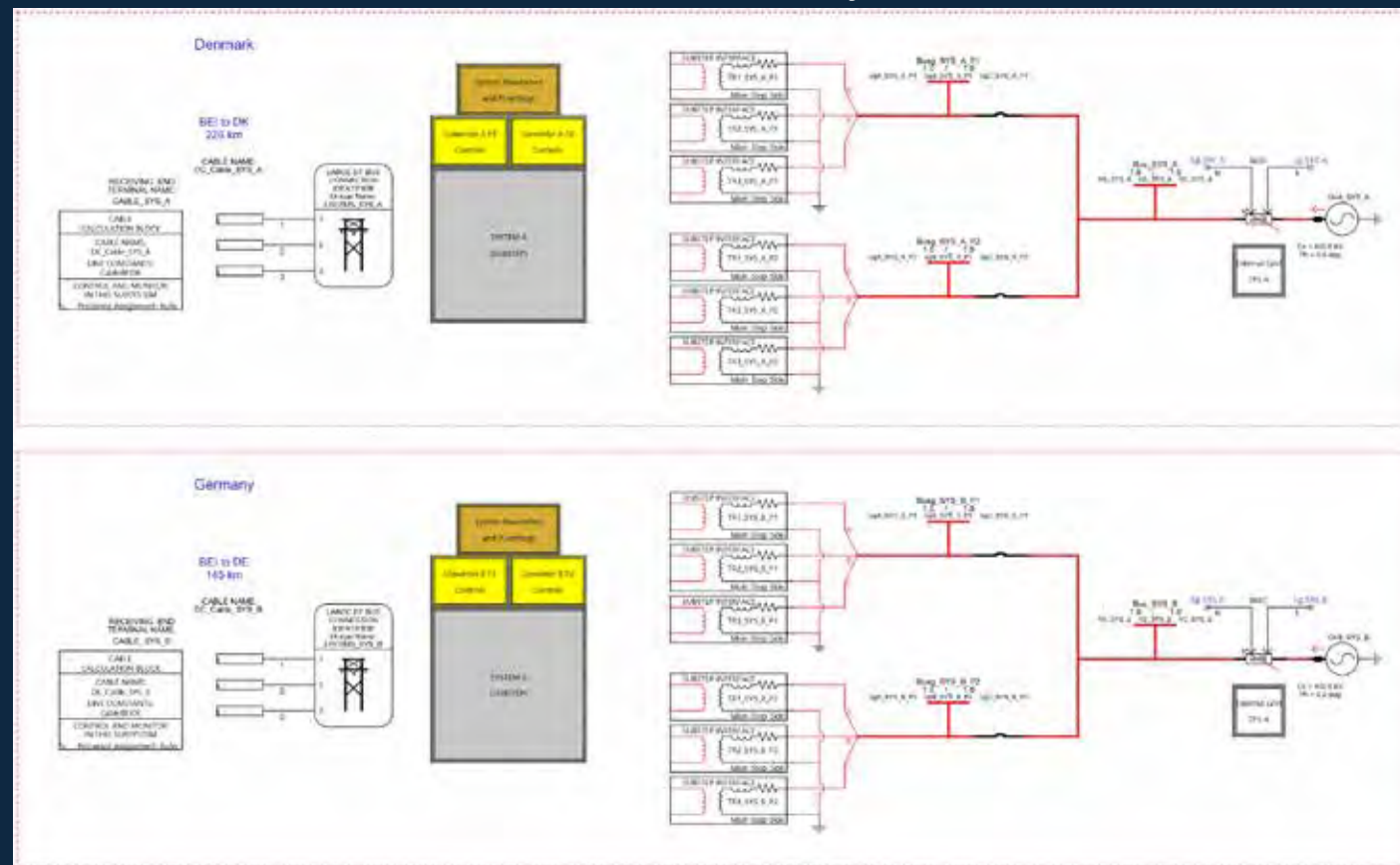
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The RTDS Model

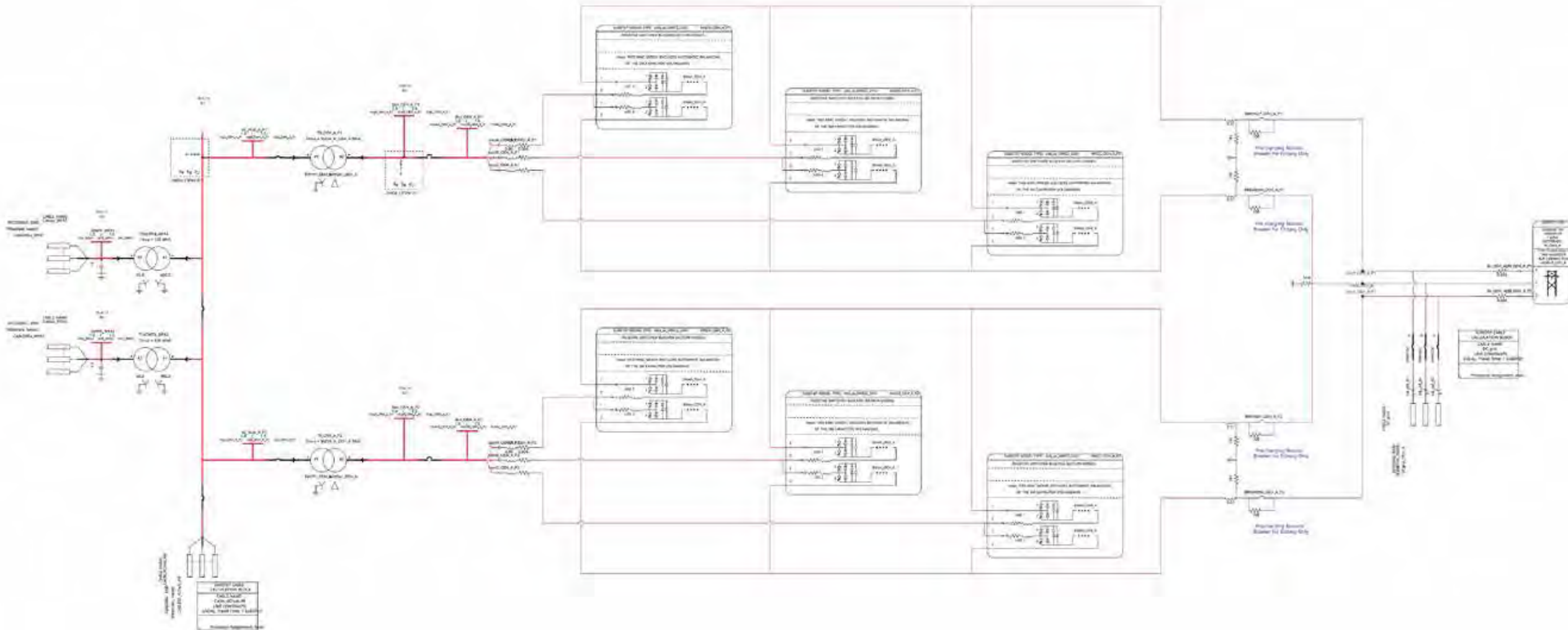
Rack 1 – Offshore System



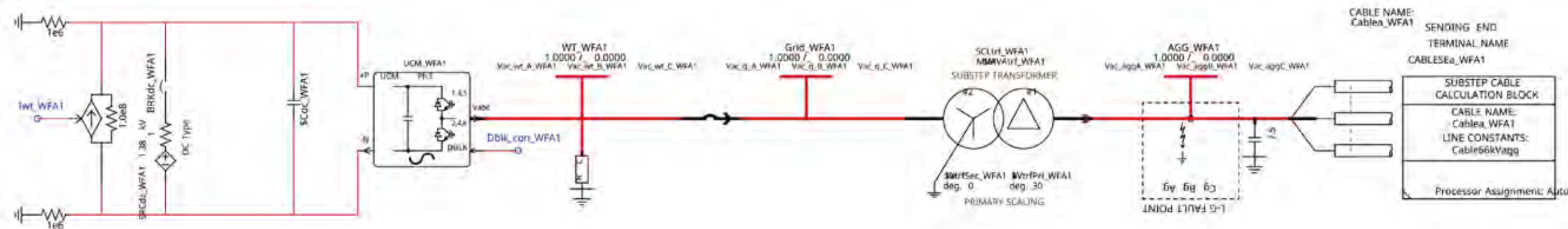
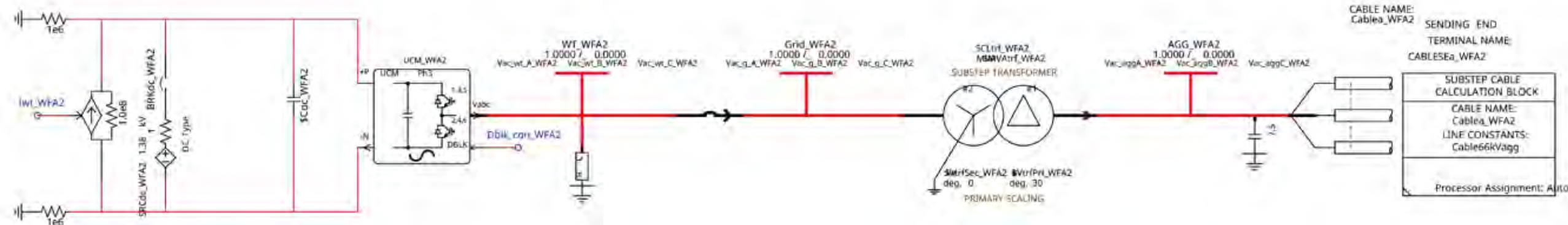
Rack 2 – Onshore System



Offshore HVDC converters – Grid Forming

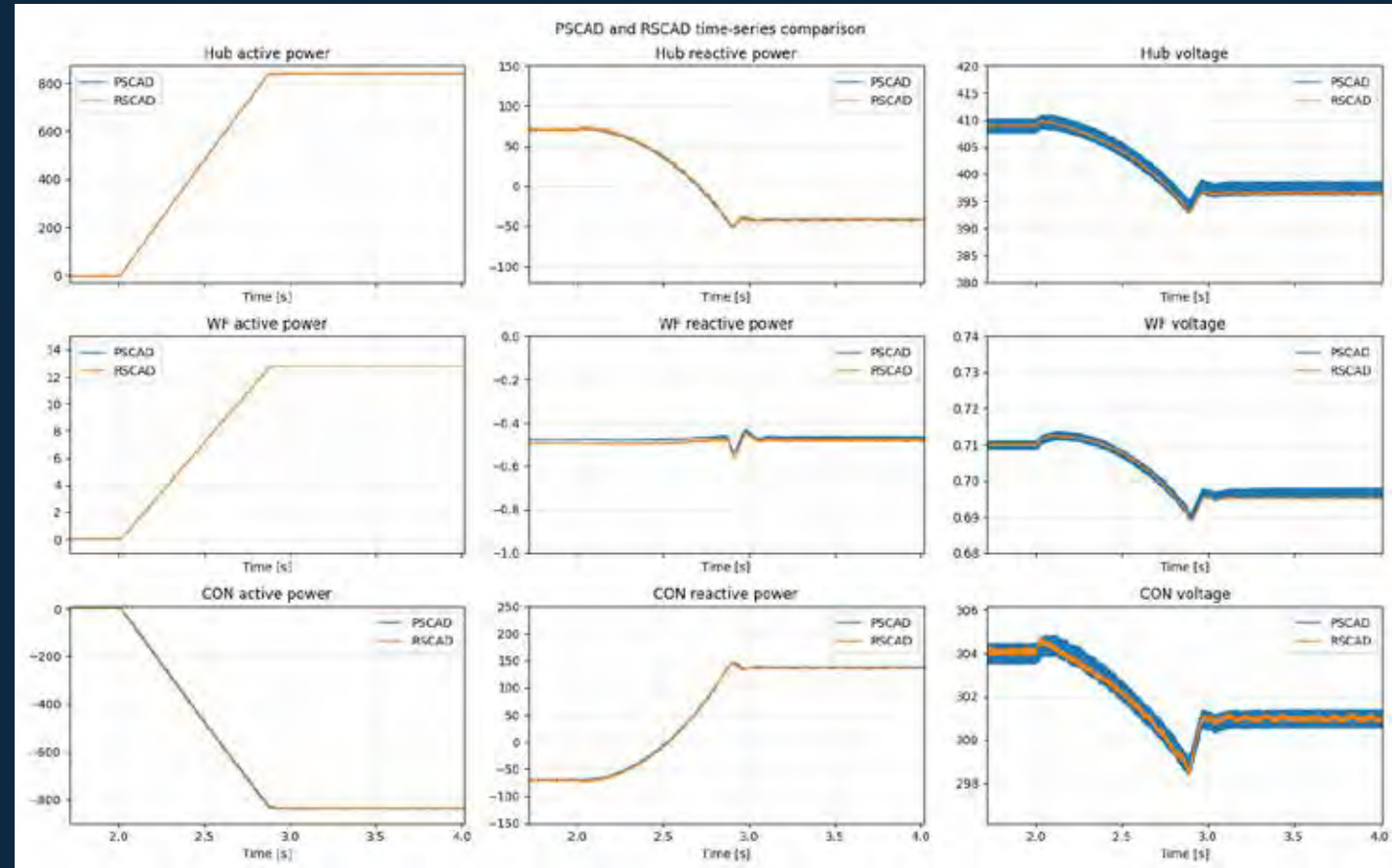


Aggregated Wind Farms



Comparison with PSCAD

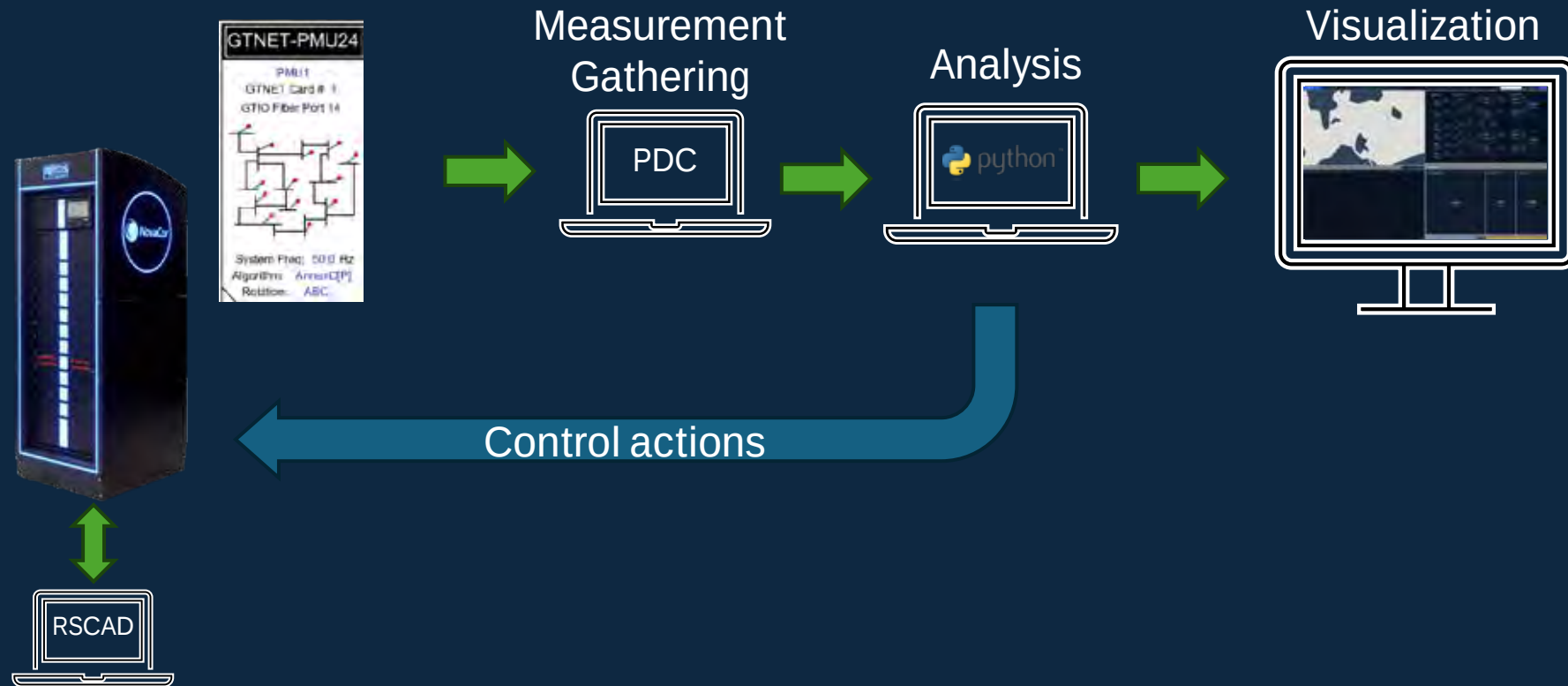
- The RSCAD model is based on a PSCAD implementation
- The two models provide nearly identical responses



Why do we use RTDS?

- Model Validation
 - Cross-validation of system models using independent simulation platforms, increasing confidence in the results.
- Computational Performance
 - Real-time simulation enables predictable execution times, even for complex systems with numerous converters, provided sufficient computational resources.
- Live Demonstrations
 - Demonstrating hub operation and dynamic interactions in a realistic, real-time simulation environment.
- Future-Proofing
 - Establishing a real-time simulation platform for future Hardware-in-the-Loop (HIL) and Software-in-the-Loop (SIL) testing.

Visualization and live demonstrations

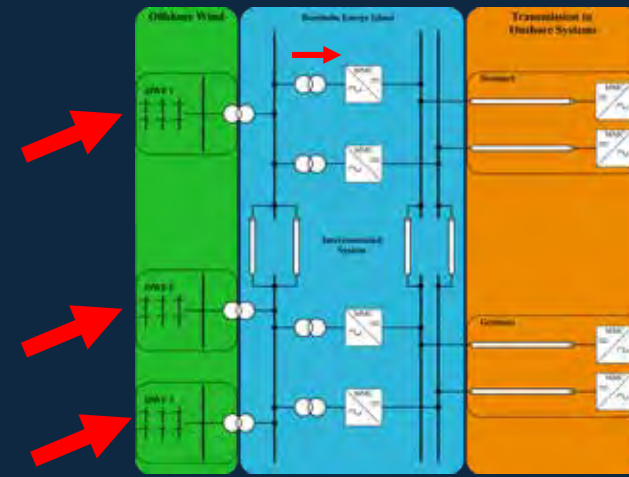
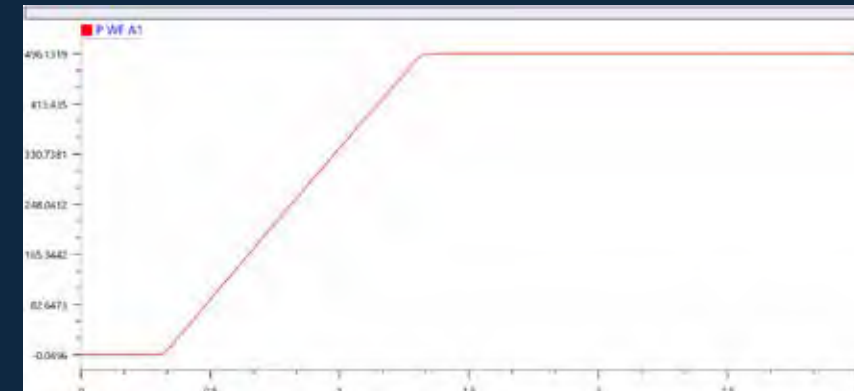
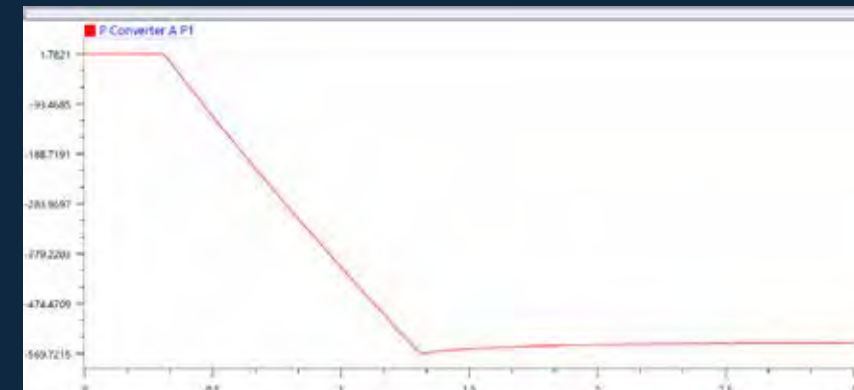






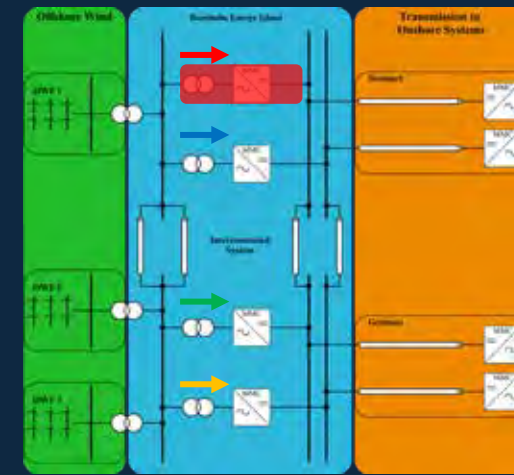
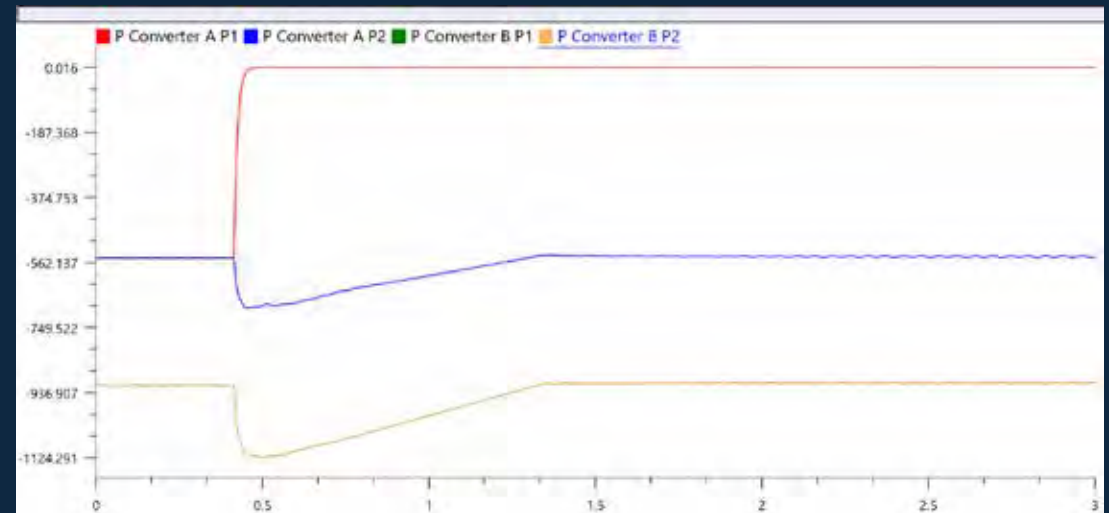
Test case breakdown

- Wind power ramps up from 0 to $\approx 3\text{GW}$



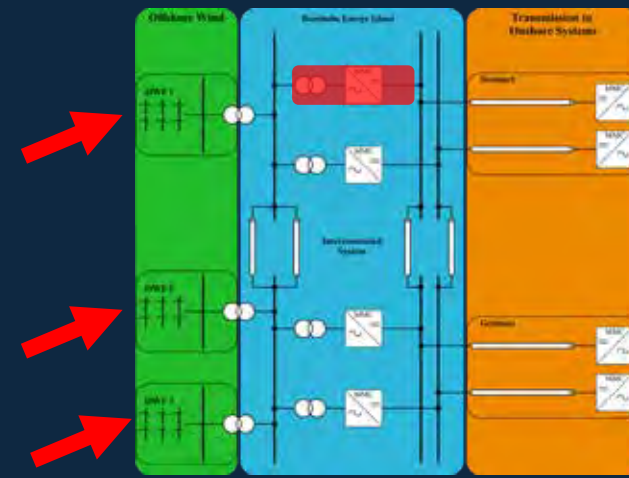
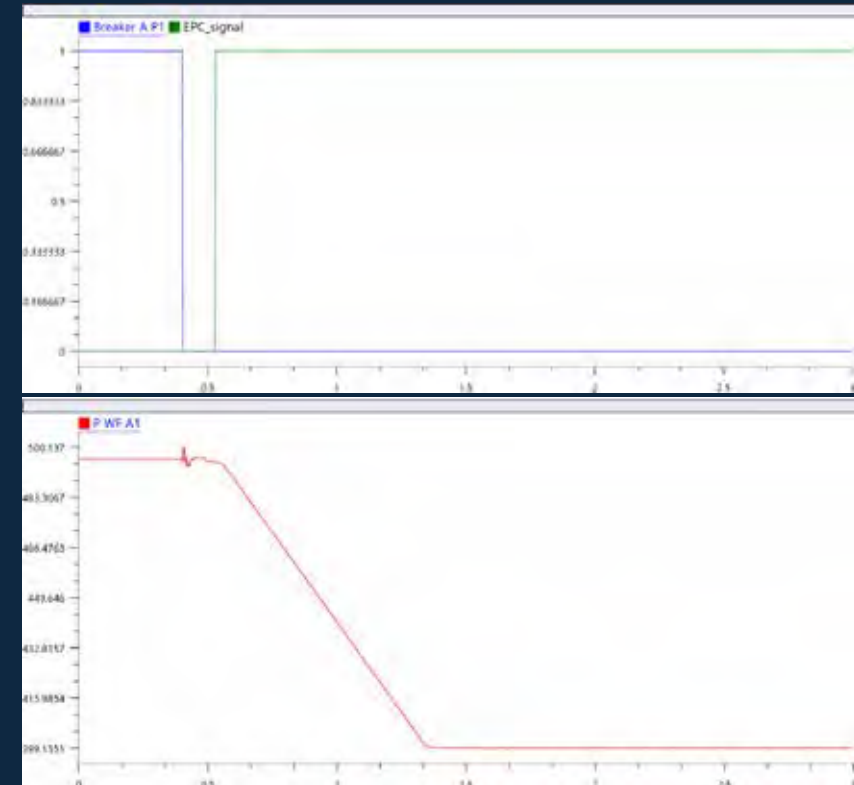
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- One 600 MW Converter trips, other converters compensate
- EPC signal is sent to the wind farms to reduce generation



Summary

- Energy Hubs/Islands are the next generation of offshore wind
- We use RTDS to model and test concepts for stable and resilient hub operation
- Using PMU measurements from the RTDS we can visualize and analyze the system operating condition in real time
- Ongoing research