PO.007

Co-Simulation of Wind Farm Operation with Model Extensions based on Modular Interface Concept

Marcus Wiens[1], Niklas Requate[1], Tobias Meyer[1]
[1]System Technology, Fraunhofer IWES, Germany,

Fraunhofer IWES

Abstract

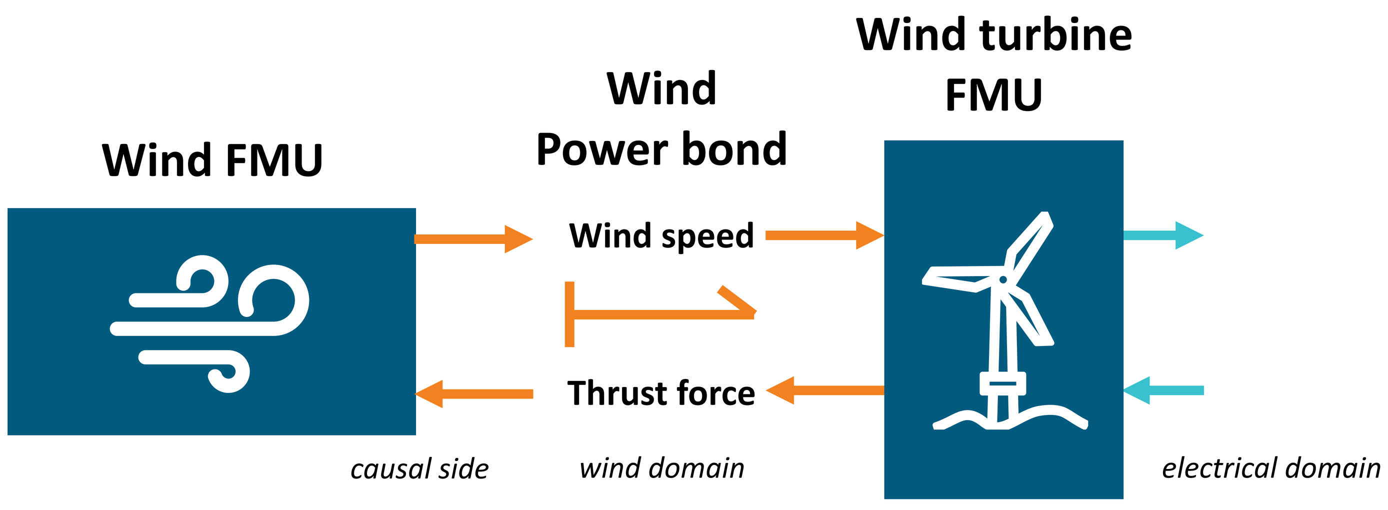
Wind farms will form a main pillar of the future energy system, to achieve a sustainable and reliable energy supply. The transition of the entire energy system to renewables increases the requirements and demands for the operation of wind farms which will need to include possibilities for energy storage like hydrogen-electrolysis, batteries, or other subcomponents in the future. Scenarios like retrofitting (shift from electricity to hydrogen production) or repowering of existing wind farms will become relevant as well as the optimal setup and operation of new wind farms. This allows for many more degrees of freedom during the design of a wind farm and its auxiliary components. We apply an interface concept to enable Co-Simulation of Wind Farm operation on different time scales and levels of detail. This enables to add new domains to the simulation and investigate coupling effects.

Objectives

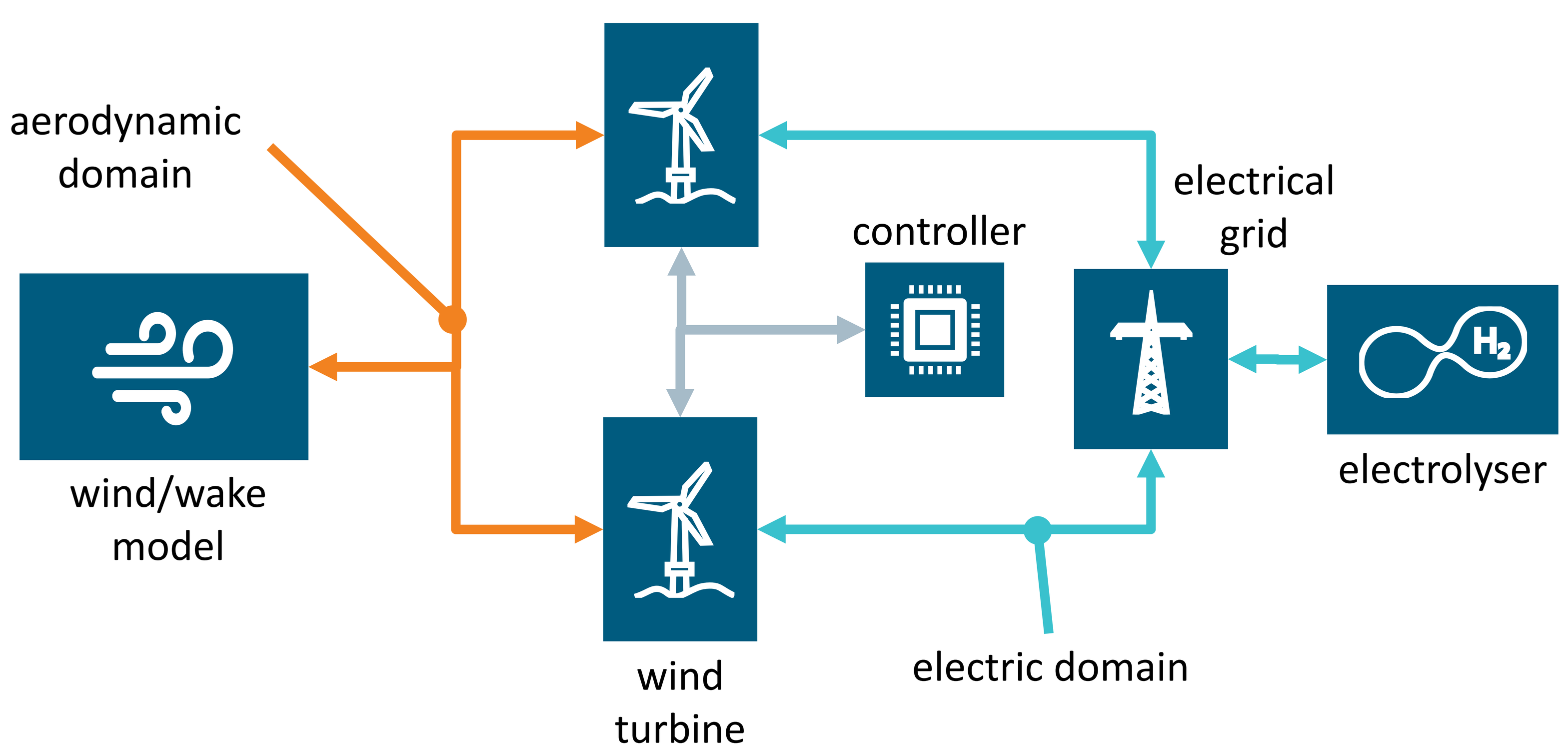
The larger number of possible technical solutions requires an efficient modeling, simulation, and evaluation approach. For this purpose, we have defined a modular interface concept, which allows a flexible and extensible setup of a wind farm model with medium fidelity. The interfaces are defined as two different types. One represents the exchange of information and the other the physical coupling due to the exchange of power. The implementation is focused on Co-Simulation of multi-domain systems[1] with Functional Mock-Up Interfaces[2]. We are using In-House tools for the demonstration, however, any other model with the same interface implementation could be used.

Methods

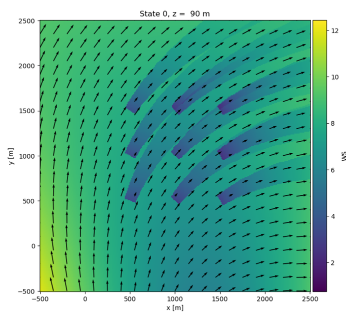
We apply the principles of bond graph theory for model coupling. In this context, the interface is thought of connectors, where two coupled models have opposite implementations of the interface.



The power bond directly translate to model interfaces for each domain. In the example, the aerodynamic domain defines the interaction of wind model and wind turbine. This makes models exchangeable when they behave in a similar way and builds the basis for the modular multidomain model. Energy is transported from the wind turbine by the electrical grid. The application of power bonds enables to add any number of consumers or providers of electrical energy by utilizing junctions to connect multiple models in a single node. Signals for controllers are described by interfaces models as well.



We use Foxes, MoWiT, and further in-house models for batteries and electrolyser, where individual inputs and outputs are mapped to the interface definitions.



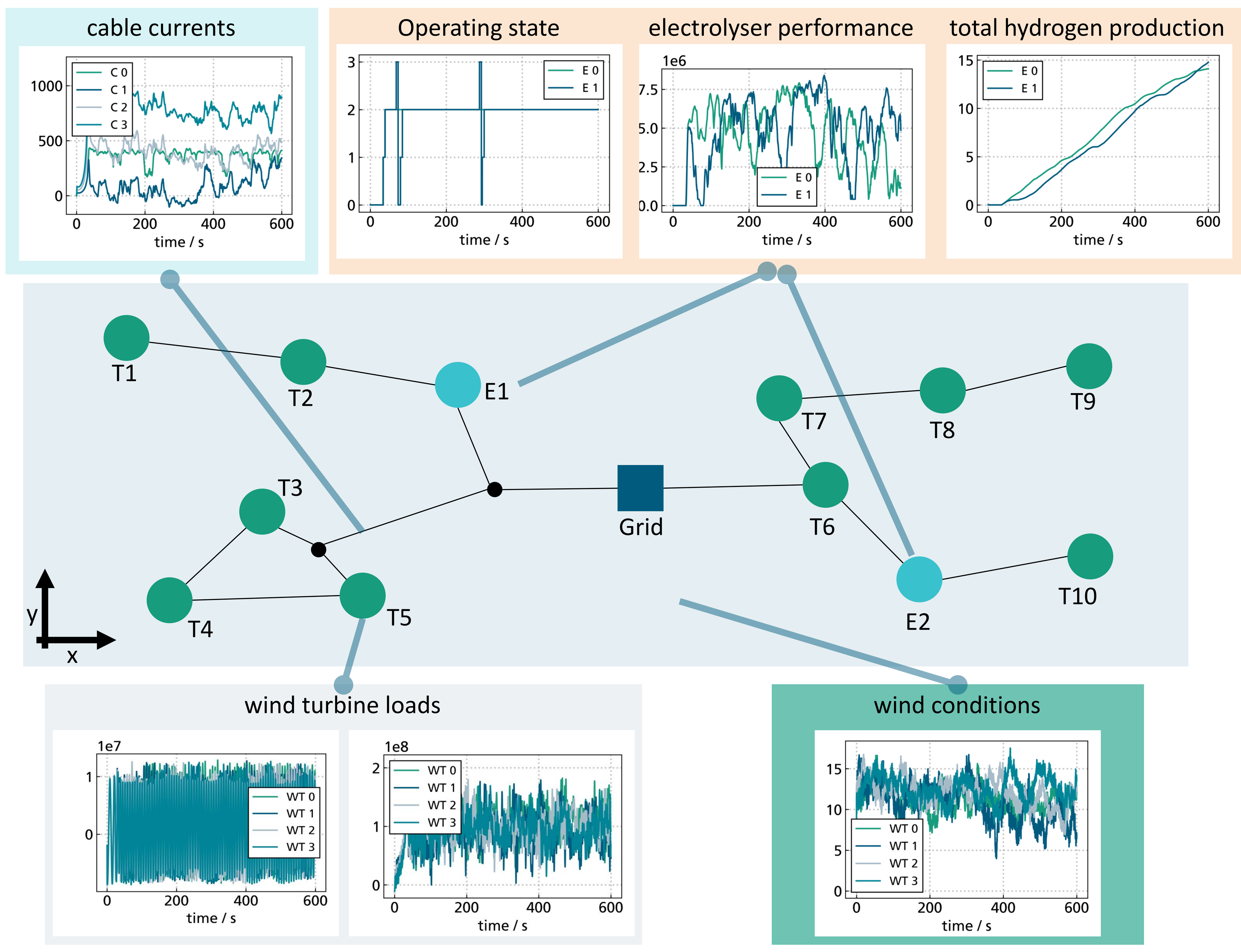
FOXES Farm Optimization and eXtended yield Evaluation Software Fraunhofer IWES

Fraunhofer IWES MoWiT Modelica® Library for Wind Turbines

An ontological description of the interfaces[3] enables the automated connection of models with a higher-level description of the model connections. Thereby, full wind farm simulation models can be generated.

Results

This modelling technique enables to simulate many different technical solutions or extensions for future wind farms with batteries or electrolyser. Furthermore, repowering of wind farms can be considered as well. Future repowering projects might need to reuse existing cable layouts or other components to save costs and materials. This can be evaluated or even be optimized by reusing parts of the models. For demonstration of Co-Simulation with the modular interface concept, we evaluate wind farm extensions to support energy yield.



Conclusions

The modular interface concept increases the reusability of already available simulation models and allows for efficient evaluations of new wind farms concepts to support investment decisions.

Further research will include detailed electrical models for electrical stability analysis and models for coupling on different scales.

References

1. M. Wiens, T. Meyer, and P. Thomas, “The Potential of FMI for the Development of Digital Twins for Large Modular Multi-Domain Systems,” in Proceedings of 14th Modelica Conference 2021, Linköping, Sweden, September 20-24, 2021, 2021, pp. 235–240.
2. Modelica Association, www.fmi-standard.org, 2023
3. Nordahl, Håvard & Rindarøy, Martin & Skjong, Stian & Kyllingstad, Lars & Walther, Dirk & Brekke, Tore. (2020). An Ontology-Based Approach for Simplified FMU Variable Connections With Automatic Verification of Semantically Correct Configuration. 10.1115/OMAE2020-18135.

MEET US AT (INSERT BOOTH NUMBER)