Sustainable Resilient Data-enabled Offshore Wind Farm and Control Co-design

The Control Room of the Future for offshore wind farms

The SUDOCO project will introduce an **innovative open-source, data-driven platform** designed to achieve an optimal equilibrium between maximizing energy production and mitigating structural loads for offshore wind farms.

SUDOCO's **Control Room of the Future** will significantly boost wind farm performance using extensive experimental data and physics-based machine learning, while integrating advanced cybersecurity measures and AI for enhanced security and data-driven decision-making.

"SUDOCO is, at the very end, a puzzle to combine different elements. Just like the famous sudoku puzzle"

Project main goals

TECHNICAL

Implement farm-wide flow control for wind turbines to optimise the balance between energy yield and structural loads.

ECONOMIC

Develop a control system for a 10% reduction in the Cost of Valued Energy (COVE) metric.

ENVIRONMENTAL

Optimise the entire wind farm system to decrease lifetime CO_2-equivalent emissions by 20%.

SOCIAL

Enhance cybersecurity to ensure an uninterrupted energy supply.

Project presentation video

Flow control

What we do

Integrated secure wind farm flow control solutions will be developed for large offshore wind farms tailored for realistic time-varying conditions

Our objectives

1. To define references wind farms
2. To develop a wind farm control software platform
3. To integrate different wind farm control techniques
4. To develop reliable, secure, and scalable control topologies

Image credit: Jason Mavrommatis, unsplash

Hardware, loads & health

What we do
Understand the impact of wind farm control on loads and health of wind turbines.

Our objectives
A model framework that precisely predicts the degradation of wind turbine components. This enables wind farm control applications to be load-aware.

Heterogeneous inflow conditions at the rotor of an offshore turbine

Value function models

What we do

Models to predict value of energy and environmental impact of wind farms. These models are fast and accurate (control-friendly) surrogate models based on real data or future energy system models.

Our objectives

- Predict the spot market, weather and environmental impact (e.g. CO_2 emission reductions) of generating wind energy on a given electricity market region
- The models can be used in short-term (forecast) and long-term (for valuation and co-design).
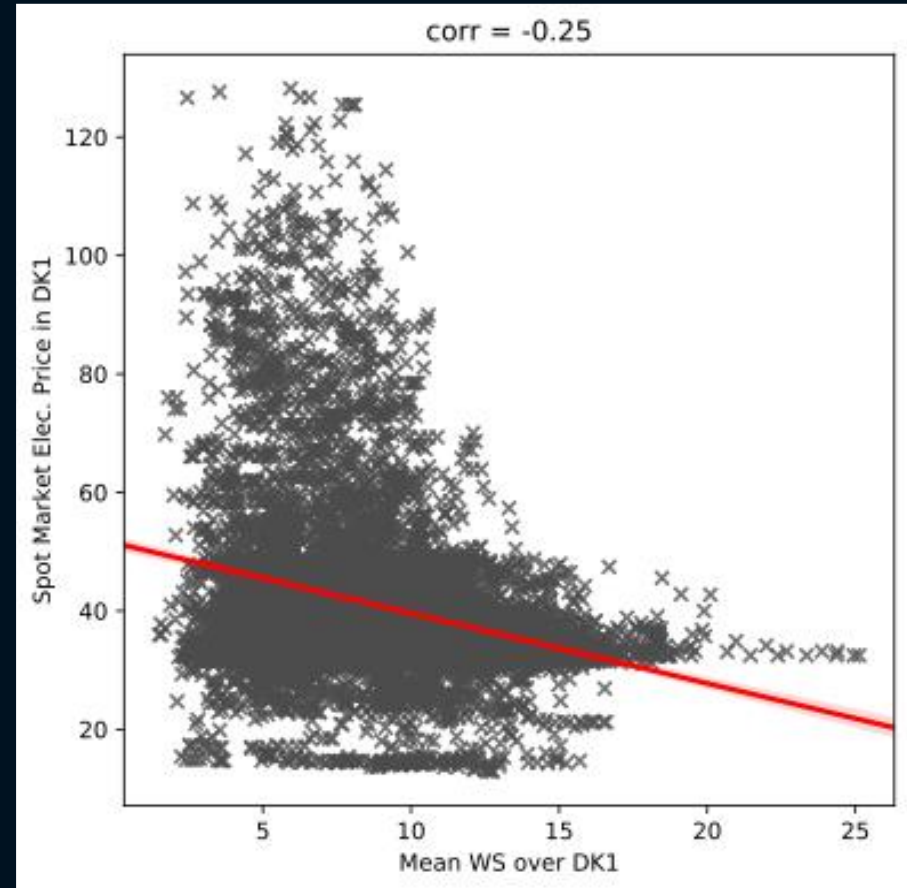
Electricity prices are negatively correlated with regional wind speed in DK

Control room of the future

What we do

Integration of wind farm flow control into the offshore wind farm business case and offshore wind farm operation.

Our objectives

- Integrate wind farm control in a holistic framework for developing an offshore wind farm project
- Develop optimised control operation strategies considering trade-offs of load versus yield, component reliability, economic and environmental value
- Integrate modelling of energy storage, focusing on batteries and hydrogen
- Implement security of supply control strategy
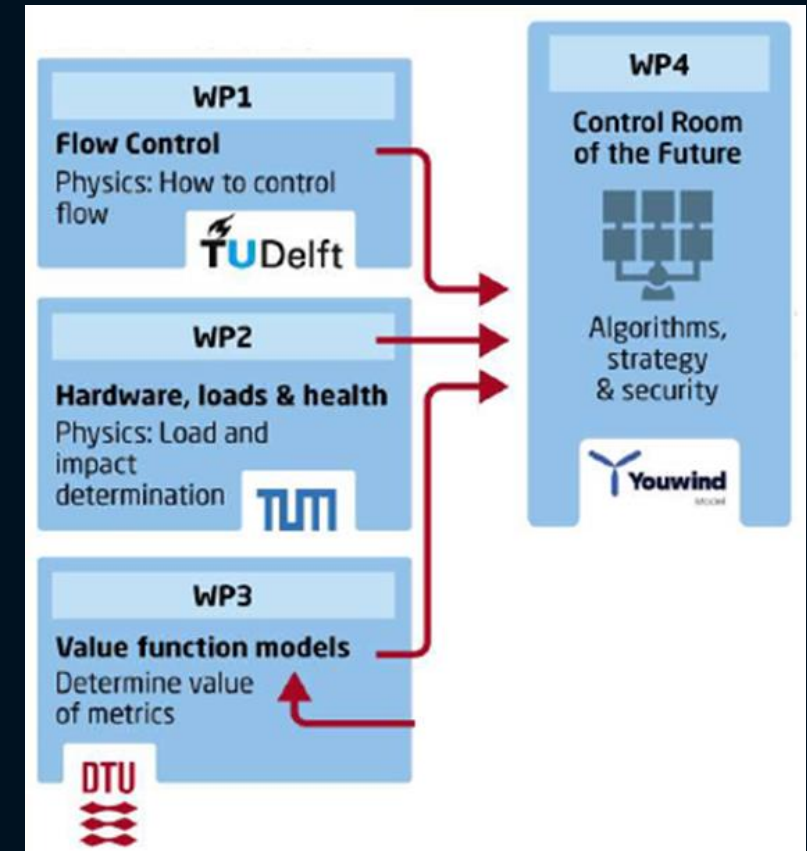
Co-design

What we do

Design of wind farms considering the added value of wind farm control strategies for environmental and economic metrics.

Our objectives

- Implement multi-objective nested optimization of wind farm design with internal wind farm control "operation" optimization
- Adapt dynamic control strategies for design problems based on simplifications and surrogates
- Integrate control co-design capability into wind farm layout design tools
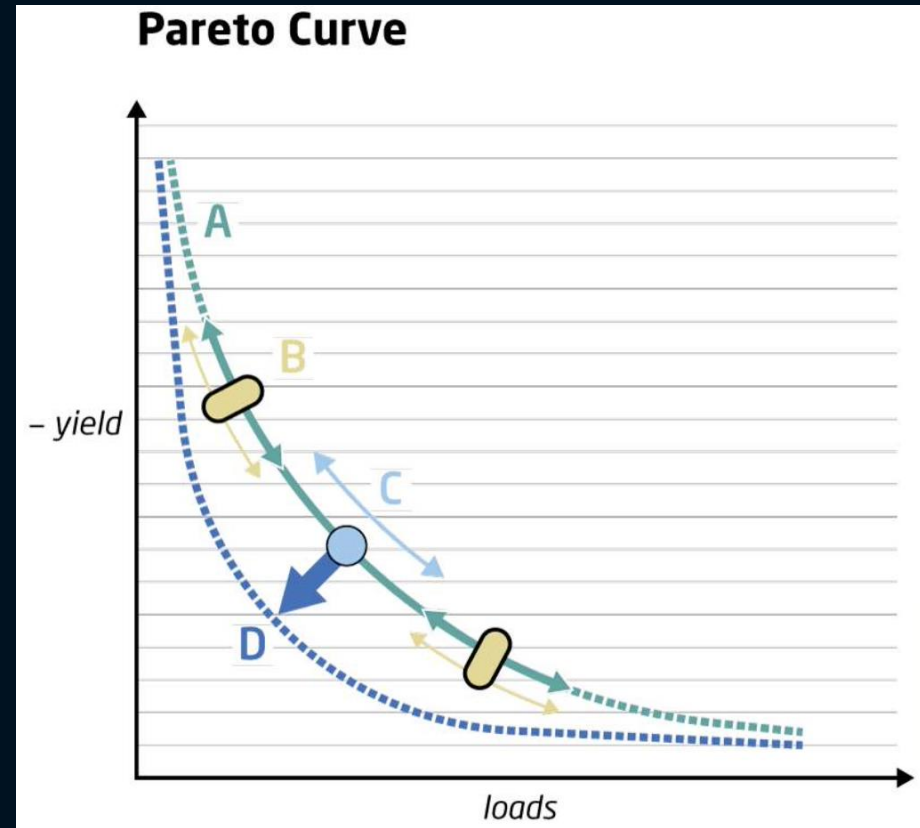
Improvement in yield and load reductions from control only (green) to co-design (blue)

Demonstration, validation and case studies

What we do

The project will demonstrate and validate the developed control algorithms, including realistic case studies.

Our objectives

SUDOCO will showcase the developed integrated wind farm control in high-fidelity simulations, commercial wind farm field datasets, and experiments at the largest wind tunnel in Europe with sophisticated scaled wind turbines.

Wind tunnel at Politecnico di Milano

SUDOCO consortium

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Thank you