Research project develops innovative models that cut offshore wind energy costs by up to 9%

Roskilde/Dublin 10 December 2024

Offshore wind turbines face higher wind speeds than onshore turbines and face strong ocean currents, requiring more robust designs and significantly higher capital costs. While they generate more energy due to stronger winds, these increased costs result in a higher levelized cost of energy (LCOE). The HIPERWIND project has developed new design simulation models that reduce the LCOE by up to 9%, thus making offshore wind turbine construction and operation more cost-effective and reliable.

This year, wind energy reached a cumulative installation capacity of 1TW. The capacity is expected to grow up to 10TW by 2050. On this scale, reducing costs by 9% is monumental.

“HIPERWIND set out to achieve a significant reduction in the LCOE by understanding how to deal with uncertainties in the wind turbine design modelling chain,” says Project Coordinator Nikolay Dimitrov from DTU Wind. “We examined how to quantify and identify various uncertainties, ranging from environmental conditions to loads and wind turbine reliability. With this information, we focused on reducing material use by better understanding model performance and reducing uncertainty. This approach helped minimize material use and lower energy costs. This methodology has demonstrated the feasibility of designing more efficient systems.”

At the core of HIPERWIND is managing uncertainties. Uncertainties translate into higher safety margins, adding materials to components, shorter maintenance cycles, and increases in the cost of financing wind farms. Uncertainty management is consequently a driver in reducing costs and risk – thereby improving the production reliability, and ultimately, the value of offshore wind.

Game changer

“HIPERWIND could be a game changer,” Clément Jacquet from EPRI Europe says. “We delivered a significant reduction of the LCOE of up to 9% - and even 10% is achievable if we consider the most optimistic case we have. In the least optimistic case, the reduction will still be 5%.” EPRI assessed the impact of HIPERWIND technologies on LCOE, requiring both a holistic approach and detailed analysis of offshore wind farm costs. This work resulted in a new, adaptable framework that EPRI will use in future projects to improve the economic efficiency of both onshore and offshore wind farms.

The project used a real-world case study involving the Teesside offshore wind farm off the coast of England, owned by project partner EDF. Data and models specific to the wind farm were used to identify and quantify uncertainties in turbine tower and foundation design. The team then assessed whether the improved knowledge could reduce costs if the wind farm were rebuilt.

HIPERWIND thereby demonstrated that using less material in turbine construction can reduce upfront costs (capital expenditure), which make up about 30% of the overall cost of energy. Additional cost reductions were achieved by scheduling maintenance during low energy price periods, boosting both cost savings and operational efficiency.

Exploitation

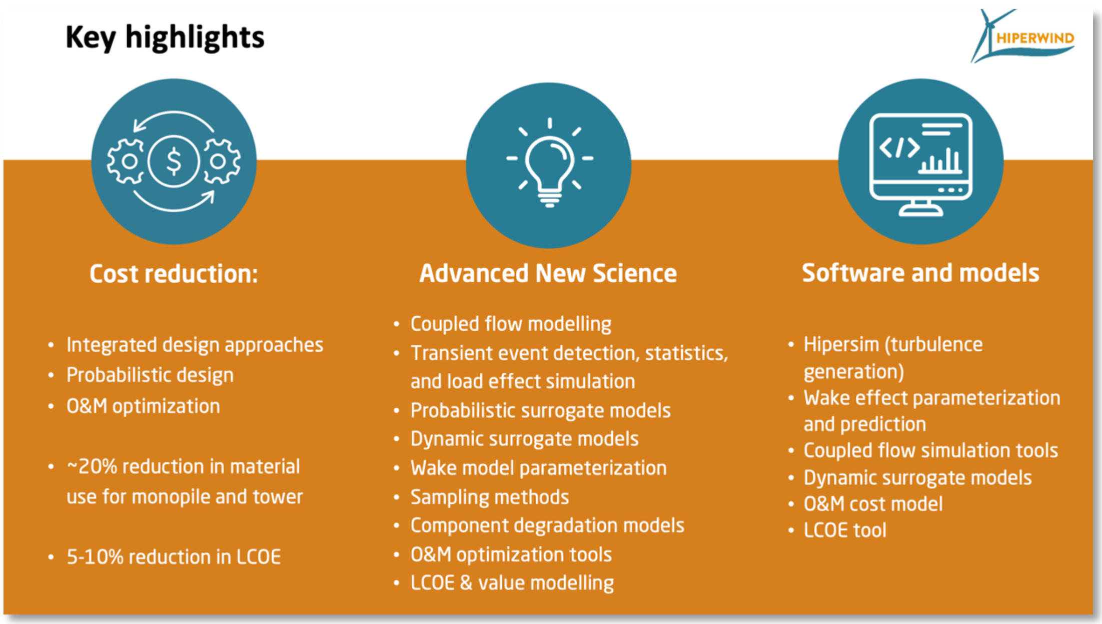
Leveraging the measured data and advanced physics-based and data-driven models, this uncertainty management and reduction philosophy was applied throughout the offshore wind turbine design modelling chain – and beyond.

IFP Energies Nouvelles (IFPEN) is also already applying HIPERWIND results, improving chain modelling by accurately quantifying wind turbine fatigue loads. “The project has produced some significant reliability design procedures that are feasible in an industrial context and thereby go beyond the research domain,” explains Martin Guiton from IFPEN. “Taking uncertainties into account, we obtain a reduction of 21% of the mass of the wind turbine structure, which is a lot”, adds his colleague, Alexis Cousin”

Likewise, ETH Zurich is now using these methodologies not just to solve wind-related problems but also earthquake-related problems, such as the seismic fragility of buildings in complex environments and the design of high-rise buildings under random wind excitation.

“The project required us to develop a new methodology from scratch to handle uncertainties in high-dimensional inputs and responses,” says Senior Scientist Stefano Marelli, Chair of Risk, Safety and Uncertainty Quantification at ETH Zürich. “Our work on surrogate modelling techniques, which accelerated algorithm development and enabled cross-partner collaboration, proved to be successful.”

Breakdown of results



Further information

The HIPERWIND consortium consisted of seven partners from both academia and industry: DTU Wind and Energy Systems, ETH Zürich, EDF, IFPEN, EPRI Europe, University of Bergen, and DNV.
This project was funded by the European Union’s Horizon 2020 Research and Innovation Programme under Grant Agreement No. 101006689 and has run for 3.5 years. It was led by DTU Wind and Energy Systems All data and publications resulting from the project are publicly available on the website: https://www.hiperwind.eu/

Watch video interviews with project partners:

- Nikolay Dimitrov, DTU Wind
- Stefano Marelli, ETH Zürich
- Martin Guiton and Alexis Cousin, IFP Energies nouvelles

- Clément Jacquet, EPRI Europe

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About DTU Wind
DTU Wind and Energy Systems is one of the world's leading wind energy research departments. Our research spans the full spectrum of wind and energy systems. From investigating nanoscale structures to macro-scale atmospheric flow; from designing the turbines of tomorrow to the digital energy solutions of the future; from developing electric power systems to exploring more democratic processes for project planning. We aim to create impact for people and society through research and innovation. And we collaborate with the entire wind energy sector to develop the most effective technologies on the planet.

About EPRI Europe
Ireland-based EPRI Europe DAC was established in 2019 by EPRI International Inc. as its European research arm. Founded in 1972, EPRI is the world's preeminent independent, non-profit energy research and development organization, with offices around the world. Our trusted experts collaborate with more than 450 companies in 45 countries, driving innovation to ensure the public has clean, safe, reliable, affordable, and equitable access to electricity across the globe. Together, shaping the future of energy®.

About IFP ENERGIES NOUVELLES (IFPEN) is a major research and training player in the fields of energy, transport and the environment. From scientific concepts within the framework of fundamental research, through to technological solutions in the context of applied research, innovation is central to its activities, hinged around four strategic directions: climate, environment and circular economy – renewable energies – sustainable mobility – responsible oil and gas. As part of the public-interest mission with which it has been tasked by the public authorities, IFPEN focuses its efforts on bringing solutions to the challenges facing society and industry in terms of energy and the climate, to support the ecological transition. An integral part of IFPEN, IFP School, its graduate engineering school, prepares future generations to take up these challenges.

About EDF

In England, Ireland, Scotland and Wales, EDF Renewables is a major renewable energy company, specialising in wind power, solar power, and battery storage technology. Our aim is to do whatever we can to ensure all our customers enjoy access to a diverse, reliable, and affordable low-carbon energy mix for decades to come.

About ETH Zürich
Freedom and individual responsibility, entrepreneurial spirit and open-mindedness: ETH Zurich stands on a bedrock of true Swiss values. Our University for Science and Technology dates back to the year 1855 when the founders of modern-day Switzerland created it as a centre of innovation and knowledge. The ETH-Chair of Risk, Safety and Uncertainty Quantification carries out research projects in the field of uncertainty quantification for engineering problems with applications in structural reliability, sensitivity analysis of computer models, surrogate modelling, model calibration and reliability-based design optimisation. We also develop the UQLab software, a unique Matlab-based platform for uncertainty quantification.

About UiB
At the University of Bergen (UiB), we conduct research and offer education across a broad spectrum of renewable energy topics, contributing to advancing the energy transition. The Renewable Energy Group focuses on developing innovative, environmentally friendly strategies to overcome challenges in harnessing ocean-based energy, particularly offshore wind. Our interdisciplinary research includes studying atmosphere-wave-ocean-structure interactions to improve energy resource forecasting over a wide range of spatiotemporal scales, multiscale and data-driven modellings of environmental and structural variability in offshore energy systems, and evaluating their environmental impacts, such as aerodynamic and underwater noise from turbines and wind farms.

About DNV
DNV is an independent assurance and risk management provider, operating in more than 100 countries. Through its broad experience and deep expertise, DNV advances safety and sustainable performance, sets industry standards, and inspires and invents solutions. Whether assessing a new ship design, qualifying technology for a floating wind farm, analysing sensor data from a gas pipeline, or certifying a food company's supply chain, DNV enables its customers and their stakeholders to manage technological and regulatory complexity with confidence. Driven by its purpose, to safeguard life, property, and the environment, DNV helps its customers seize opportunities and tackle the risks arising from global transformations. DNV is a trusted voice for many of the world's most successful and forward-thinking companies.