FF4EuroHPC Success Story

High-Fidelity Modeling for Small Wind Turbines

Organizations

EUNICE WIND SA is an SME member of the EUNICE ENERGY GROUP. Since 2001 the group has been active from the construction of power generation units up to the development and operation of renewable energy source (RES) investments. EUNICE manufactures a 50-kW small wind turbine called EW16 Thetis.

FEAC Engineering P.C. is a Greek engineering & consulting SME, highly specialized in simulation-driven product development & physics-based Digital Twins.

End User

EUNICE ENERGY GROUP

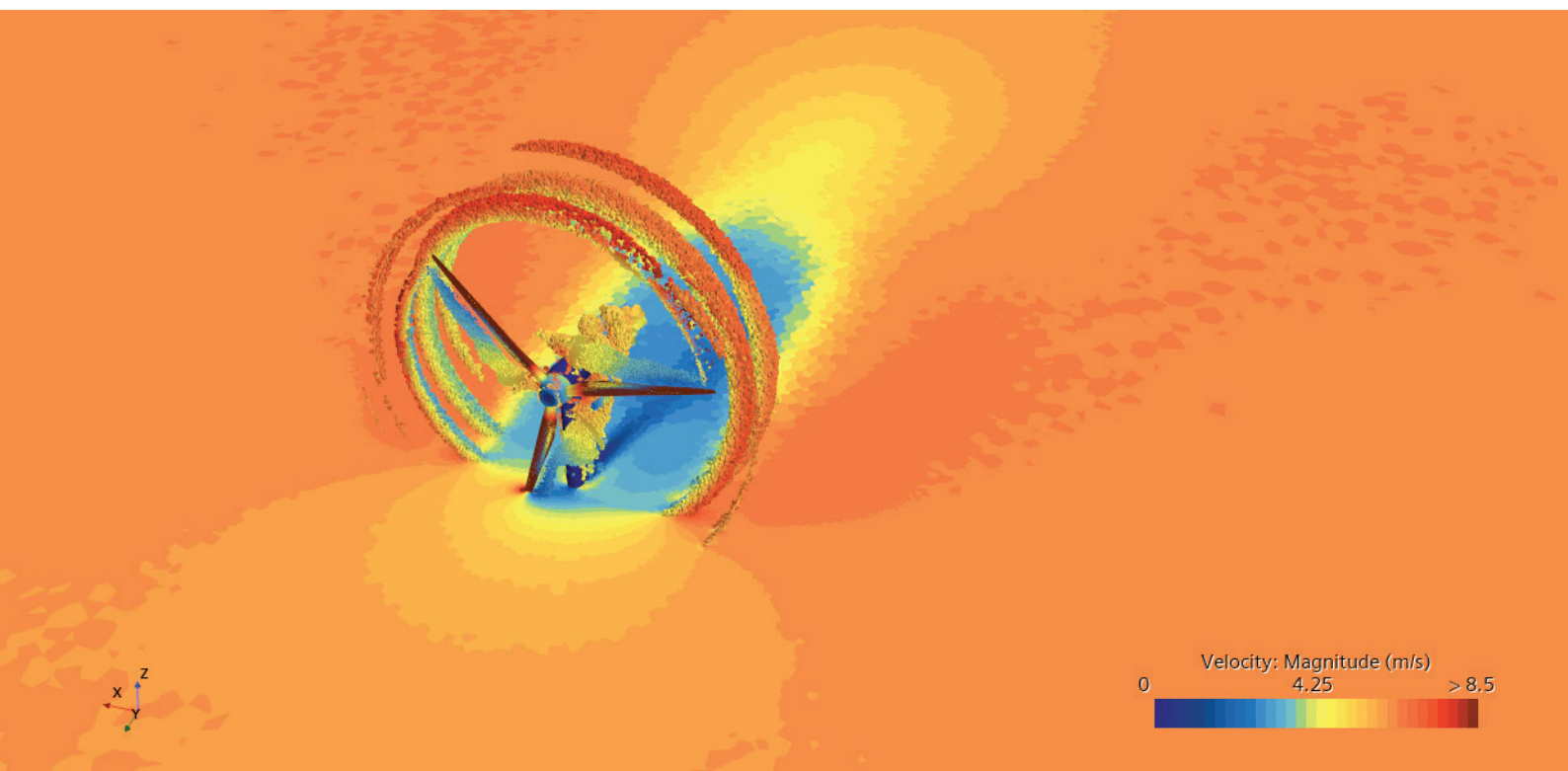
Technology Expert

FEAC

The Challenge

Wind energy is one of the fastest-growing renewable energy sources in the world. As the demand for clean energy continues to grow, the wind industry is facing pressure to enhance the efficiency and cost-effectiveness of wind turbines. One way to achieve these goals is to replace physical testing with CFD simulations. However, the accurate prediction of temporal and spatial scales within a multiscale CFD model requires advanced meshing techniques and high-resolution numerical models.

A specific objective of the experiment was to construct a precise numerical model of EUNICE's EW16 Thetis wind turbine in order to enhance its operational efficiency. However, such simulations necessitate significant computational resources and know-how which exceed the computing capacity of EUNICE. FEAC Engineering was entrusted with addressing the aforementioned challenge by leveraging its extensive knowledge and expertise in the simulation sector.



Industry Sector
Environment

Technology used:
HPC,
CFD Simulation

The Solution

The partners developed sophisticated CFD simulation models using highly dense computational meshes consisting of over 50 million cells, a reduced time step approach, and the Detached Eddy Simulation method to test and optimize wind turbine performance at the actual operation site, including information about terrain and elevation available from satellite images in the CFD model. In total, about 485,000 CPU hours were used for the simulations, which were validated with an experimental data set.

The Impact

For EUNICE, the material and permitting cost of constructing a new wind turbine solely for testing purposes is approximately €300,000. Replacing those tests with HPC-based CFD simulations reduces costs to only 10-17% of the total expense, depending on the complexity of the HPC calculations.

Since stresses on the blades are known from the simulation results, predictive maintenance costs can be reduced. Together with an increase in energy yield, achieved with the optimal blade pitch strategy found in the experiment, this gives EUNICE a competitive advantage .

FEAC Engineering gained more expertise in the wind energy sector and valuable experience in high-fidelity simulations by utilizing large-scale HPC resources.

Furthermore, the developed solution leads to the improvement of emerging designs and more advanced wind turbine models that contribute to environmental sustainability and avoid unnecessary waste from non-recyclable composite materials utilized in the test turbines' construction.

Benefits

- Tests by HPC simulation could reduce the testing costs by up to 83% compared to a typical physical test installation.
- Increased competitiveness from faster design cycles and lower operational expenditure, which lead to higher levelized cost of electricity.
- Assist the European Commission directives towards a green and sustainable future.