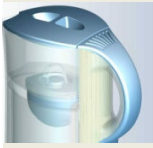


▶ **ANALYSIS & DESIGN**  
ASSESSMENT OF PRODUCT  
PERFORMANCE & DESIGN  
DEVELOPMENT



▶ **RESEARCH & DEVELOPMENT**  
FEASIBILITY OF NEW CONCEPTS &  
UNDERSTANDING CORE PHYSICS



▶ **PRODUCT DEVELOPMENT**  
WORKING AS PART OF YOUR  
MULTIDISCIPLINARY TEAM -  
FROM CONCEPT TO MARKET

- Renewable Energy
- Optimisation
- Design Study

# Intelligent

# Fluid Solutions

SPECIALISTS IN THE APPLICATION OF FLUIDS ENGINEERING & CFD FOR ENGINEERING & DESIGN

## Virtual Assessment & Optimisation of Wind Farm Configuration

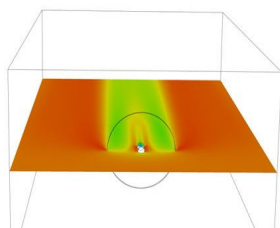
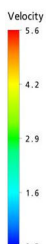
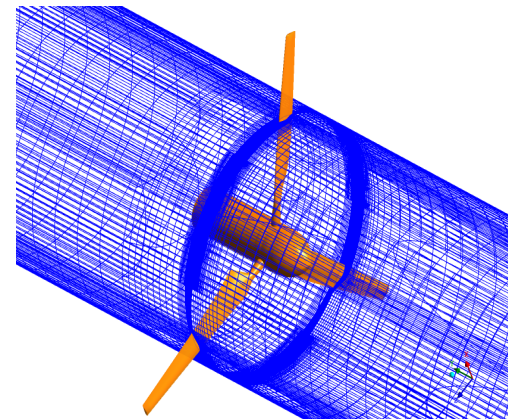
Wind power and wind turbines are arguably the most developed of the alternative sources of renewable energy. Wind turbine technology is maturing, leading to increased operating confidence and designs of increasing sophistication.

However, when installed, the turbines are generally grouped into clusters or wind farms. Originally these farms were located on-shore, however, due to planning issues offshore farms are seen to be the way forward even though the cost and difficulty increase significantly.

Modern analysis techniques are able to predict individual design turbine

performance with an adequate level of accuracy. However, it is impractical to apply these techniques to an entire wind farm. In addition, turbines in a wind farm can operate in off-design conditions due to the influence of the other turbines and non-uniform flow fields generated by the local wind characteristics and terrain.

The current project aimed to demonstrate a virtual wind farm optimisation procedure that combines simplified turbine modelling with statistically based optimisation technology. The objective of the work was to demonstrate the optimisation methodology through a simple case study.

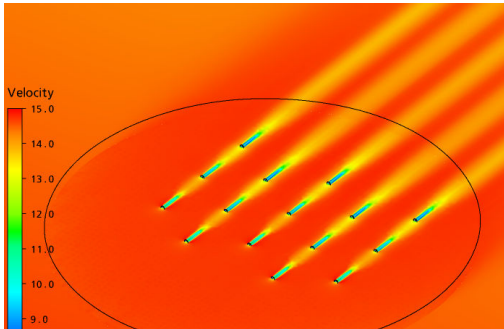


## Project Summary

Although the performance of an individual wind turbine can now be predicted with an adequate level of accuracy for a design condition, it is impractical to use this technology to assess the performance of turbines grouped in wind farms and affected by the local terrain. This work demonstrates a new CFD-based wind farm optimisation methodology that combines a simplified wind turbine CFD treatment with a statistically based optimisation procedure. The new methodology is used to optimise an onshore wind farm that uses a simplified but generic cost function in order to demonstrate the power of the new methodology.

# Getting the Most From Engineering Analysis

*Using advanced engineering analysis to predict and develop device performance and hence gain confidence and reduce technical risk*



The accurate prediction of wind farm performance is critical to the planning of installation capacity and on maximising the return on the significant initial investment.

A simplified turbine CFD-based modelling approach has been validated against both experimental data and the full 3D CFD analysis of a wind turbine. The simplified approach uses blade-element theory to correctly approximate the time-averaged properties of the turbine wake. Thus the developed methodology has the ability to capture turbine-turbine interaction.

The simplified methodology was used to predict the aggregate performance of alternative wind farm configurations. However, the power of the methodology is unlocked when combined with a statistically based optimisation procedure. The wind farm configuration can now be optimised to maximise a specified goodness function.

The current work aimed to demonstrate the optimisation methodology for a generic onshore wind farm case. The case considered a wind farm consisting of a staggered arrangement of 2MW Vestas V80 turbines in a 2 x 3km area.

A simple but generic goodness function was developed for the exercise. The aim was to optimise the wind farm configuration to develop the maximum power per unit cost. The cost function consisted of a fixed cost component and a variable cost component. The relative value of the components was obtained from published literature.

The computational resources required for the optimisation procedure is significant even when using the simplified CFD-based approach.

The analysis used 15 wind farm configurations to optimise the streamwise and spanwise spacing of the turbines in the given area to maximise the output power for minimum cost. The analysis procedure successfully identified a unique maximum of the given goodness function.

This work has demonstrated the ability of the new optimisation methodology to significantly improve wind farm yields.

**INTELLIGENT  
ENGINEERING**  
Experience &  
Technology



The advent of inexpensive computer power and commercially available analysis software has made possible the full virtual modeling of product performance. However, the technology is still developing in terms of accuracy and reliability. Thus CFD is not a substitute for traditional engineering methods, but rather compliments the existing processes



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