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Enhancing LiDAR application for boosting Wind Farm Efficiency

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Introduction

The development of large offshore wind farms is hindered by the lack of easy, affordable and accurate measurement of the wind conditions and the performance of the wind turbines and the wind farm. Building meteorological masts is impractical and unaffordable to measure wind conditions in the wind farm.

ECN aims to reduce the uncertainty in measurements of the wind and/or to ease wind measurements by applying LiDAR technology. The capability to perform accurate, efficient and effective measurements during the development and operation of an offshore wind farm contributes to: (1) **Accurate assessment of the wind resource**, (2) **Effective and reliable power performance assessments** and (3) **The optimized operation of wind turbines and farms**.

Unique is that this is achieved using multiple ground based and/or nacelle based LiDARs in combination with full scale R&D turbines.

Source: Google Earth

Large LiDAR measurement campaign

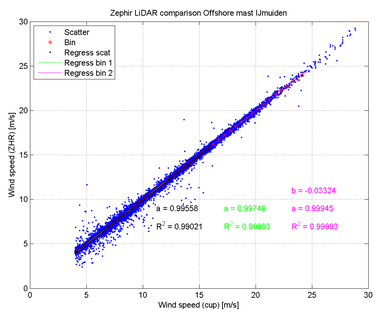
In order to achieve these goals **measurement campaigns** are performed in the ECN test site Wieringermeer, which is a near shore site consisting of flat, agricultural terrain [1].

For LiDAR application in w**ind resource assessment** two WindCube V2 (incl and excl FCR) and a Zephir 300 are installed near meteorological masts and a similar LiDAR is installed at (inside!) the offshore meteorological mast IJmuiden.

The WindCubes are installed near a full scale 2.5MW research turbine and a Wind Iris is placed on its nacelle for **power performance** and yaw misalignment assessment.

Multiple nacelle based and ground based LiDARs, including a WindCube 100S will be installed at the full scale research wind farm for **optimized operation**. In addition a DTU short range wind scanner experiment was organized in the ECN scaled wind farm for the same purpose.

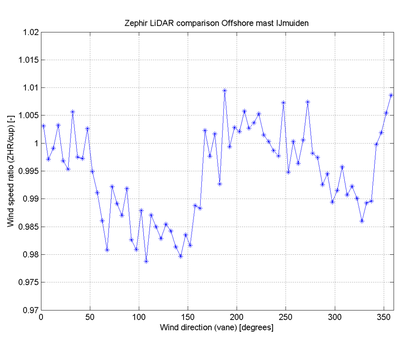
Wind Resource Assessment



From the FLOW/RWE offshore meteorological mast IJmuiden [2], 75km from shore in the North sea, 1½ year of data have been analyzed, where the Zephir LiDAR data at 90m have been compared with cup anemometer data at 92m.

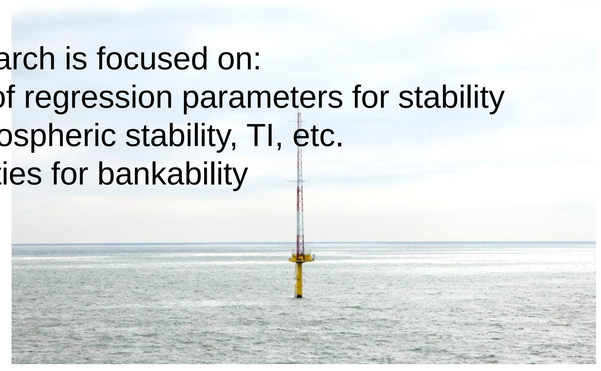
Initial results show that:

- The LiDAR passes the ‘NORSEWInD’ standard [3]
- Wind direction variation of the ratio (ZHR/cup)



Further research is focused on:

- Variation of regression parameters for stability Time, atmospheric stability, TI, etc.
- Uncertainties for bankability



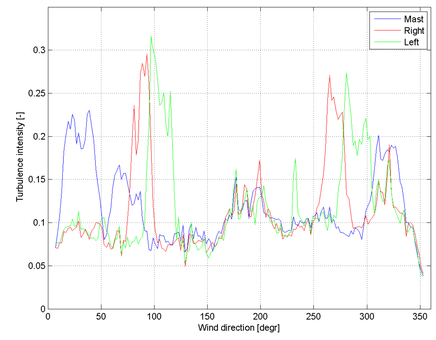
FLOW/RWE Offshore meteorological mast

Nacelle LiDAR based Power Perfomance

The Wind Iris from Avent Lidar Technology is installed on a 2.5MW research turbine on the ECN test site. 4 months of data have been considered with LiDAR measurements at 200m (distance to mast) and cup/mast measurements at hub height.

Initial results show the (radial) TI of both beams and of the mast measurements. They clearly show all wakes of turbines in the surroundings for performance assessment.

Power performance, yaw misalignment and stand-alone operation will be assessed with the LiDAR system [4,5].



Full scale R&D turbines wind field mapping

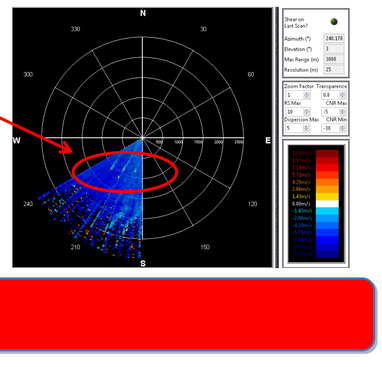
The NORCOWE consortium and ECN are setting up a measurement campaign with multiple instruments

Schematic overview of the planned layout

Aim is detailed wake and wind field measurements

- 3 ground based WindCube V1
- Nacelle mouned Zephir 300 (backward looking)
- Long range WindCube 100S
- Meteorological mast
- Temperature profiler
- Research turbines

Wakes of research turbines



1st scan of WindCube 100S made by Valeri-Marie Kumer NORCOWE, University of Bergen

WindScanner in Scaled Wind Farm

A measurement campaign with 3 DTU short range windscanners [6] in the ECN scaled wind farm [7] was organized in the last week of June 2013.

The scaled wind farm consists of 10 turbines (h=7.5m, 10kW) and 14 meteorological masts with cups, vanes and sonic anemometers.

The measurements focused on turbine wake measurements, farm wake measurements and wind field validation with special attention to turbulent structures.

Acknowledgements

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