

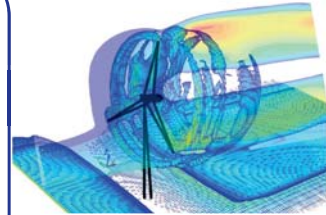
# Modelling of Lillgrund Wind Farm: Effect of Wind Direction

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## Motivation

The recent years have shown dramatic development of offshore wind energy due to the better wind speeds availability compared to on land. The wakes of upstream turbines affect the flow field of the ones behind them, decreasing power production and increasing mechanical loading. The power production from a wind farm depends mainly on wind magnitude and direction, therefore quantitative and qualitative assessment of wind farm performance under different direction is necessary. In the present study, OffWindSolver<sup>[1]</sup> tool and OffWindEng tool are used to characterize the wind direction effect on the power production from the Lillgrund offshore wind farm.

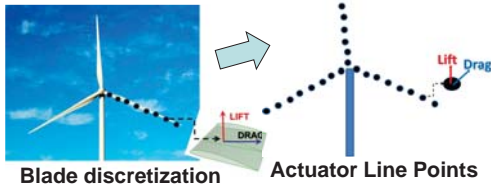


flow through wind turbine

### OffWindSolver model

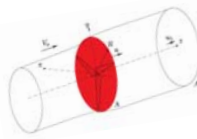
#### Actuator Line Turbine Model

- Blade is model as a set of discret points along each blade: Aerodynamics blade forces are governed by velocities obtained locally & tabulated 2D aerofoil data



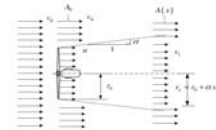
#### Actuator Disc Model

- The actuator disk model resolve the rotor as a porous disk. AD



### OffWindEng model

- Model of the wake effect includes:
  - Effects of wind direction
  - Wind speed time delay
  - Cumulative impact of multiple shadowing,

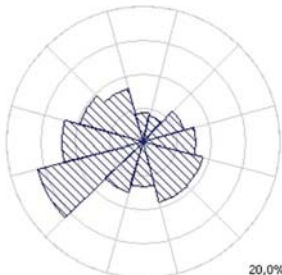
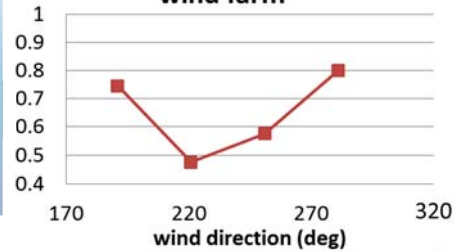


$$u_{i, power}^3 = \frac{\int_{S_{rotor}} u^2 ds}{S_{rotor}}$$

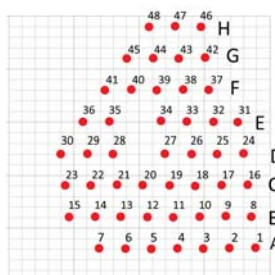
## Influence of the wind direction on the wind farm production:

- **Minimum power production is obtained for around 220° wind direction (WD)**
  - Almost total shading of the wind turbines situated in the lee of other turbine
  - the power production is only 50% from designed wind farm power (without any wake loss)
- **Maximum power production is obtained for around 280° wind direction (WD)**
  - The shading for the wind turbine is low
  - the power production is around 80% from designed wind farm power (without any wake loss)

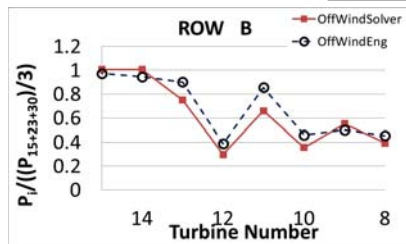
### relative power deficit of the wind farm



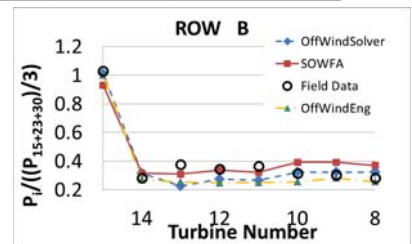
Wind rose - Lillgrund wind farm



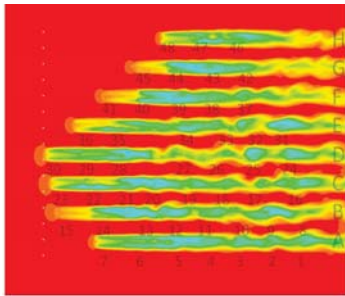
Lillgrund wind farm



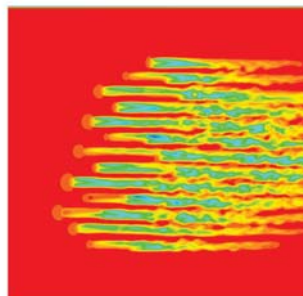
Wind power- wind direction = 281°



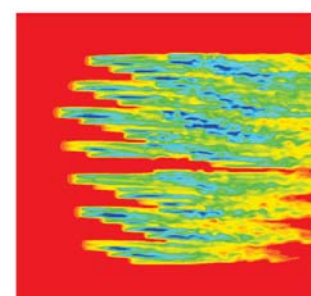
Wind power- wind direction = 221°



Velocity Distribution - WD = 221°



Velocity Distribution - WD = 251°



Velocity Distribution - WD = 281°



Aerodynamics of the flow through wind turbine gate

### Acknowledgments

The OffWind project is supported by the **Nordic Energy Research**

