

More efficient wind farms by the use of different height wind turbines

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Our experiment: The wind tunnel tests

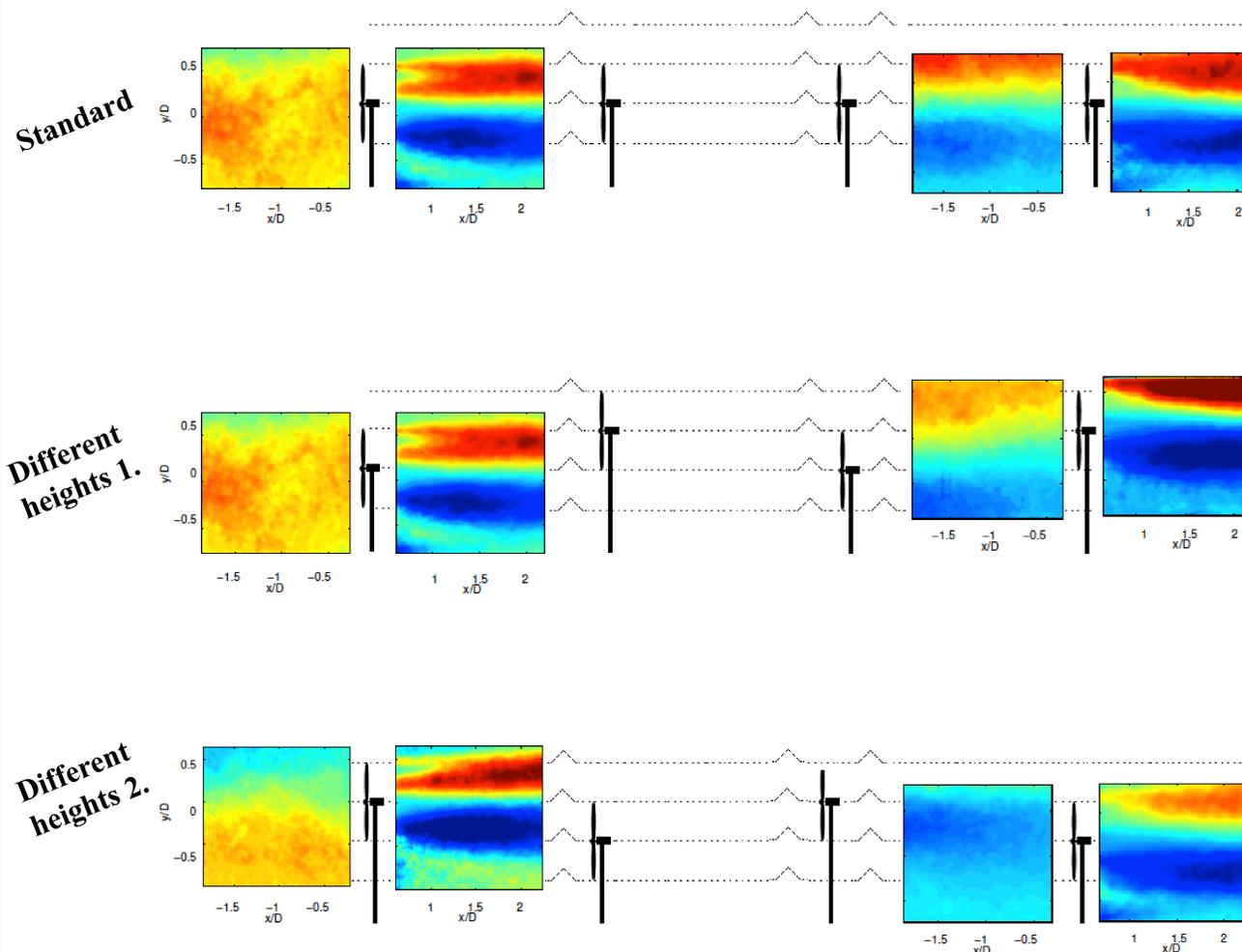
In a wind tunnel, we have tested three different wind farms by measuring the wake effects and the power production.

How do we quantify the wakes?

The wakes are quantified in a wind tunnel by measuring the flux of turbulent kinetic energy through the wind turbine rotors. The difference between the inflow to the rotors and what is produced by the rotors must be maximized.

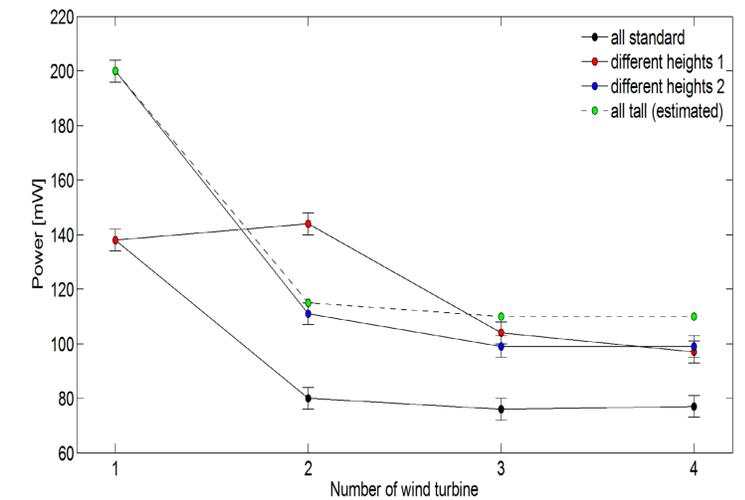
Our results: wakes and power production

In the figure below, the wakes behind the first and the fourth wind turbine are shown. As expected, the wake effects are dramatically reduced in the wind farms with different heights.



Power production: A remarkable result

- Wind farms with different turbine heights produce 30-35% more than a standard wind farm
- A wind farm with only tall wind turbines produce 45% more (estimated)



Towards more efficient wind farms

Considering the increased costs of installing taller masts, wind farms with different mast heights might prove a powerful way to optimize future wind farms.

Comparison with standard wind farm	Different height	Only tall
Energy production	30-35% higher	45% higher
Installation costs	transport tall masts	transport all masts
Material costs	63% higher	126% higher
Maintenance costs	tall masts shorter lifetime	all masts shorter life time
Aesthetics	?	No effect

Wake effects reduce the production

When wind turbines are placed in a farm, the production is severely decreased because the wind turbines shadow each other from the wind. This happens every day, e.g. at Horns Rev offshore wind farm shown on the left. The reason is that turbulent wakes form downstream of the wind turbines.

How much do the wakes reduce the production?

The effect of the wakes depend on

- Spacing between the wind turbines – the larger rotors, the larger distance needed
- The number of wind turbines - The second wind turbine produces 40% less than the first, the third, fourth, fifth etc. 45% less than the first

Our idea: Different mast heights

If the wind turbines in the wind farm have different mast heights, the wake effects reduce and therefore the power production will increase.