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Sea-land interaction influence on wind turbine power performance

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The study of vertical wind profiles measured at the Danish National Test Site for Wind Turbines at Høvsøre at the Danish west coast, offers an excellent opportunity to analyse sea-land interaction on wind turbine power production.

The test site has been in operation for $2^1/_2$ years and has been analysed for a variety of site and meteorology influences. The comprehensive amount of the data was gained from cup anemometers, wind vanes, temperatures and differential temperatures and sonics mounted on meteorology masts at heights of 10, 40, 60, 80, 100, 116.5 and 160 m. These data showed that the sea-land air flow is adequately described by the classical sea-land interaction model. The flow is divided into three regions, a)from the coast line to the wind turbine a boundary layer determined by the sea at 100 m height (approximately hub-height of a typical commercial wind turbine) builds up, b)a boundary layer growth depending on the distance from the coastal line (approximately blade tip position in downward position), and c)a mixing layer between these two. The paper examines on the different wind profiles depending on the bulk Richardson number Ri_B. Power curves are derived for wind profiles under different stability conditions with an aerodynamical code Hawc2 for a hypothetical megawatt size wind turbine. The simulations show that extreme wind shear results in nearly 10% change of C_P and that variations of annual energy production occur for varying stability conditions. In particular the analysis has shown, that the stability results in extreme shear and low turbulence during winter and spring seasons , causing significant changes in the power curve.