ABSTRACT

This work presents the results from an experiment run in the wind tunnel at the Norwegian University of Science and Technology (NTNU) for both a tubular and truss tower and compares the velocities in the tower shadow for these two alternatives. The findings are that the truss tower wake has lower energy spectra and turbulence intensities and a higher mean wind velocity than for the tubular tower case. This indicates that the loads caused by the tower shadow of the truss tower will be smaller.

KEY WORDS: Wind turbine; truss tower; downwind; tower shadow; vortex shedding; wind tunnel experiment; theoretical model.

INTRODUCTION

From the start of the modern wind turbine era up until today the growth in wind turbine size has been tremendous, ranging from the smaller kW size into today’s MW size. In addition to increasing power output, the larger wind turbines also have a substantially larger weight. As the weight scales to the cube and the extracted power only scales to the square it is obvious that this growth to continuously increasing size cannot continue (Moe, 2007).

Instead of using the same technology and up-scaling it to larger size, as has been the trend during recent years, one could rather look at other layouts and other component designs. One alternative approach could be to use a downwind rotor.

One benefit of using of a downwind rotor is that the blades do not run the same risk of striking the tower during bending as when they are mounted upwind of the tower. Hence softer blades which both are more compliant in gusts and impact loads can be used (Lee and Flay, 1999). Acceptance of lower blade stiffness can mean lower weight and cost. Further, lower weight can lower the loads transferred onto the wind turbine nacelle and tower, which in turn will affect the whole system design towards a more cost efficient wind turbine.

As can be expected a downwind mounted rotor will give rise to larger and more fluctuating tower interferences than its upwind counterpart. Using a truss tower instead of the traditional tubular tower the shadow effect and hence the cyclic fatigue loading on the downwind rotor could be reduced. In addition, according to Long and Moe (2007), a truss tower can save up to 50 % of the material compared to a tubular tower. This estimate is for an upwind rotor configuration. Looking at a downwind rotor configuration the material savings could be even more if the blades are specially designed. The blades will become lighter for downwind rotors and hence further reduce the loading on the tower.

Tower interference has been investigated by many researchers. Chattot (2006) shows that even for upwind wind turbines the tower interference is an important factor in the unsteady working conditions of the blades. This becomes even more important when looking at downwind rotors (Glasgow, Miller and Corrigan, 1981).

Thresher, Wright and Hershberg (1986) compared a numerical model with experiments for a downwind rotor. They looked at the response on the blade as it passed through the tower shadow region and found that the numerical results were significantly higher than the experimental measurements, indicating that their pie-shaped tower shadow model was too simplistic to capture what actually happened in the tower shadow region.

Powles (1983) introduced a semi-empirical model with a cosine bell shaped function for the tower wake behind a single cylinder,