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Effect of Rain on Vertical Axis Wind Turbines

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Abstract

Results are presented that demonstrate that rain will have a significant effect on the output of a vertical axis wind turbine. The experiments were carried out in the climatic wind tunnel at the University of Nottingham where water was sprayed into the wind tunnel to simulate several rainfall rates. The rain had the effect of increasing the drag, slowing the rotational speed of the wind turbine and decreasing the Power for the equivalent wind speed. The increasing in the drag has the additional effect of decreasing the optimal coefficient of performance as the rainfall rate is increased. Similar studies in airfoil performance in the rain have shown that the increase in drag and decrease in lift is related to the chord length of the airfoil and so could potentially be larger for larger turbine blades. This could have an effect on the control strategy necessary for controlling wind turbine performance and will need to be studied further.

Keywords: renewable energy, Wind power, optimal tip speed ratio, precipitation.

Introduction

In order that the more ambitious targets being set around the world for wind power production can be met, it is necessary to understand all the factors that might affect wind power production. Once a significant portion of the power is derived from intermittent sources it becomes increasingly important to be able to be able to predict how production will vary with the weather so that back-up power can be ramped up in time [1].

One area that has not undergone any significant research is the effect of rain on wind turbine performance. There have been several contradictory reports in recent literature. One paper suggests that the power increases after rain, and this has been attributed to the cleaning of soiled blades [2]. Other work has suggested that the increased mass density during rain will improve the performance of the turbine due to changes in humidity despite the fact that humidity decreases the density of air.

Corrigan and Demiglio [3] reported a 27% decrease in power output in rain in the 80's, but there have been few follow on studies to investigate this and none for VAWT. Nebel and Molly [4] noted similar results to [3] while another study showed that for a different type of rain and turbine there could be a 3% power output increase [5]. This is a confusing state of affairs and more work needs to be carried out in this area if wind power is to achieve its goal especially offshore or in wetter climates.

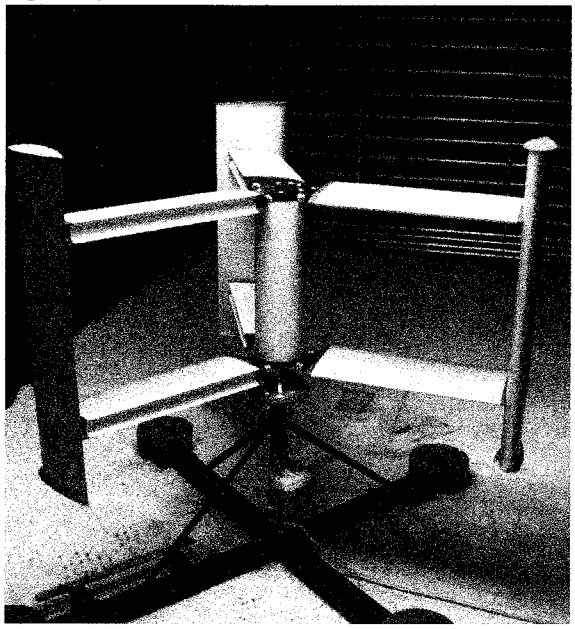

Figure 1: Image of the Ropatec (150W) [6] wind turbine used in this study.

Domestic production of wind energy is not as cost effective as large wind farm production and typically has a capacity factor of the order of 1-2% compared to a wind farm which has a capacity factor of the order 25-30%. In general domestic wind-turbines have simpler power control systems and are more prone to the variability of the wind in the turbulent boundary layer closer to the ground, making them less efficient compared to large turbines. Recent studies suggest that most of these turbines do not produce the power output that the manufacturers have suggested based on their tests in dry wind tunnels and therefore are less economically viable than initial studies suggested [7]. Reductions in power output due to rain would have a larger financial impact on owners of these turbines and could go some way to explaining the lower than predicted power