MEMORANDUM

To:	Joe Duddy	At:	Kings Langley (Beaufort Court)
From:	Peter Stuart	At:	Kings Langley (Beaufort Court)
Date:	30 March 2012	Ref:	TC01-023368

Subject: High Wind Speed Shutdown Modelling

1 Introduction

Most onshore wind turbines shutdown when the ambient wind speed at hub height exceeds 25m/s. Grid operators need to model abrupt changes of wind farm output due to high wind speed shutdown. Signals of both reference wind speed and direction are supplied to grid operators as part of grid code compliance. This document examines the modelling of high wind speed shutdown from these signals.

2 Analysis

11 years of operational data from a RES owned onshore wind farm in the UK was examined. The wind speed and direction recorded at a permanent met mast was used as a proxy for the signals sent to the grid operator. A table of the number of turbines running per wind speed and direction was extracted from the 10-minute SCADA [1]. Figure 1 summarises the results for the predominant directions where sufficient data exists at higher wind speeds.

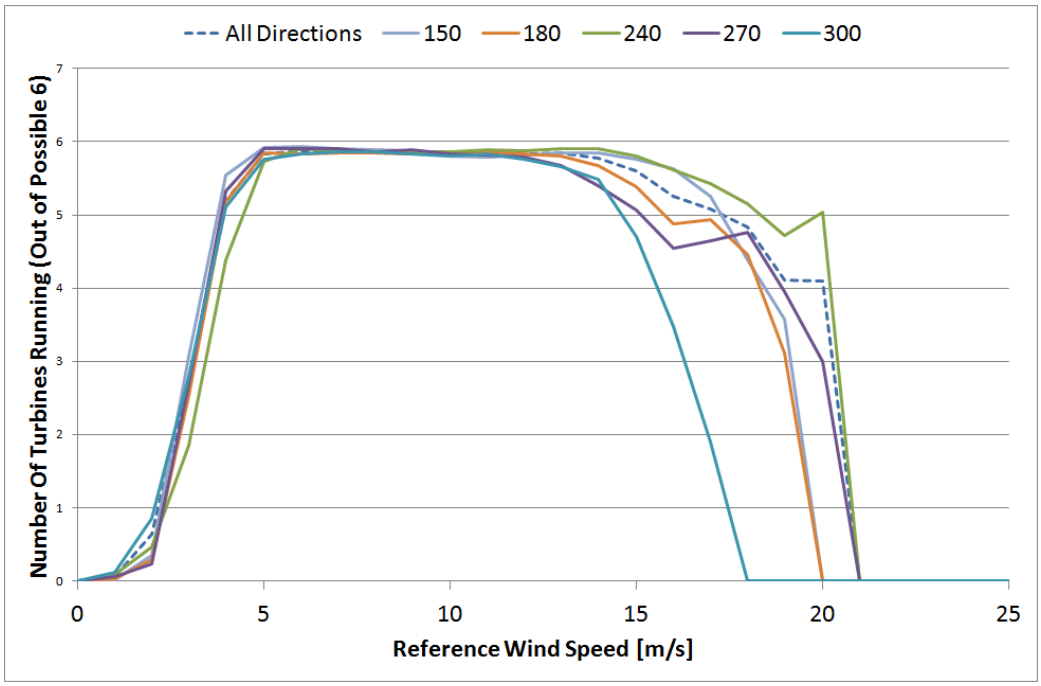

Figure 1. Number of turbines operating (out of a possible six) for direction sectors centered on 150, 180, 240, 270 and 300 (30 degree bin width) and all directions combined.

The following is apparent:

- A simple lookup of turbine shutdown based on the turbines' power curve (which has a shutdown wind speed of 25m/s) is unsuitable. This is because of the difference between the wind speed at the met mast and the turbine locations (an effect known as speed up). Caution is therefore required when using a reference wind speed that is it used in combination with an appropriate model of turbine performance.

- The shutdown behaviour varies by direction sector. This is because the speed up is dependent on the wind direction. Hence any model of turbine shutdown must take into account both the reference wind speed and the reference direction.

- The shutdown behaviour is site dependent (because the speed up is site dependent).

In practice a turbine shutdown model is required prior to the start of operation and therefore cannot be derived as presented here. In principle an analytical model could be derived prior to operation and would need to take account of site specific wind speed up. Specific details of the turbines' control system should also be considered so that the response of the turbine to variations in wind speed can be represented. RES propose to work in cooperation with grid operators to derive better models of turbine shutdown and precisely define the reference variables they should be used in combination with.

3 References

[1] "Turbines Running by Wind Speed and Direction at" RES Calculation
http://ecm1/livelink/livelink.exe/properties/19590181