TALL TOWER INVESTIGATIONS OF MISSOURI WINDS

Progress report 5 – September 26th, 2007

General

The two towers operating under this project have now been collecting data for more than a year. In this report we detail the results of the first year's observations and the comparison of these to the model wind map. The major finding is that the wind speeds observed have been lower than those predicted using the wind map of Missouri commissioned by the Missouri Department of Natural Resources.

Tower Instrumentation and Data Collection

The two towers being used for the project funded by Kansas City Power and Light are both operational. The first in Miami, MO was set up on 30th June 2006 and the second, at Raytown (Kansas City), on 25th July 2006. Both have operated since those dates with data being collected. The Raytown tower has a working cellphone modem which is allowing us to automatically download data each day. Significant icing affected the towers in mid-January leading to loss of data for a period and it is suspected that a limited amount of damage was sustained during this storm. In particular, data from channel 3 on the Miami tower has not been recording good data and it is suspected that a wiring connection to the sensor was loosened by the ice. By visual inspection it can be seen that the anemometer appears to be operating, so it is uncertain what the problem is. Unfortunately, without employing a crew to climb the tower and survey (and possibly repair) it is not certain whether this is indeed the problem. However, due to the redundancy of the systems in place, good data continues to be collected at both sites.

Annual Records

In the tables below are simple monthly means of wind speed recorded by each of the anemometers on each of the towers. For both towers we now have a complete year of data, and the results presented are for that first complete year but no longer. The data has been re-analyzed such that the figures presented here may not be the same as previously presented. In particular, it was noticed that the anemometers downwind of the tower structure recorded lower speeds than those on the upwind side when the wind was from a direction parallel to the booms, i.e. the instrument was sheltered by the tower. Therefore, to obtain the best estimate we selected the higher speed at each time interval and produced a single value for each height on each tower.

In the case of Miami the annual mean is made up of 8715 hours of data, the equivalent of 363.1 days, of which 8482 hours are good data, or 353.4 days. The annual mean wind at 67m of 6.41 m/s compares to the wind map value at 70m of 6.82 m/s, while that at 93m of 6.90 m/s compares to the wind map value at 100m of 7.37 m/s. This corresponds to an average available wind power of 315 W m^{-2}, compared to the wind map projection of 395 W m^{-2} at 100m.

For Raytown there are 8712 hours of data (363 days), of which 8404 hours are good (350.2 days). The 67m mean wind of 5.25 m/s compares to the wind map's prediction of 5.63 m/s, while the

93m wind of 5.92 m/s is less than the wind map's 6.25 m/s. This corresponds to an average available wind power of 180 W m^{-2}, compared to the wind map projection of 321 W m^{-2} at 100m.

Therefore the mean annual speeds observed are of the order of 0.4 m/s less than those predicted by the wind map. This appears to be consistent across all the towers in the project and may reflect a genuine problem with the wind map assessment or that the year for which we have made observations has been less windy than the climatological average for some reason.

Month	67 m	93 m	114 m
July 2006	5.17	5.77	5.36
August 2006	5.34	6.00	6.64
September 2006	5.70	6.28	6.77
October 2006	6.72	7.52	8.21
November 2006	6.74	7.53	8.04
December 2006	7.24	8.17	9.06
January 2007	6.89	7.53	8.23
February 2007	6.82	7.16	7.92
March 2007	7.83	8.18	9.46
April 2007	7.14	7.41	8.39
May 2007	5.99	5.76	7.21
June 2007	5.51	5.61	6.62
Year (Jul 06 - Jun 07)	**6.38**	**6.83**	**7.68**

Table 1: Monthly average wind speed (in m s^{-1}) for height of the Miami tower.

Raytown

Month	67m	93 m	142 m
August 2006	4.23	4.92	5.74
September 2006	4.71	5.50	6.34
October 2006	5.15	6.12	7.15
November 2006	5.11	6.16	7.35
December 2006	5.43	6.51	7.74
January 2007	5.90	6.68	7.28
February 2007	5.59	6.26	6.92
March 2007	5.89	6.78	7.62
April 2007	5.87	6.66	7.26
May 2007	4.69	5.64	6.45
June 2007	4.59	5.40	6.06
July 2007	4.05	4.84	5.48
Year (Aug 06 – Jul 07)	**5.25**	**5.92**	**6.55**

Table 2: Monthly average wind speed (in m s^{-1}) for each channel of the Raytown tower.

Table 3 shows the proportion of the time the wind at each tower exceeds certain threshold values which may be of interest to a developer. Winds below 3 m/s are generally considered calm and are excluded from some analyses (e.g. calculations of wind shear), while 4.5 m/s is generally considered as the threshold for utility scale turbines to turn and produce any power. The threshold of 7 m/s is usually considered as the approximate level at which power generation becomes efficient and economical, while speeds above 9 m/s or so can start to reduce turbine efficiency.

	Miami	**Raytown**
Time > 3 m/s	92	90.4
Time > 4.5 m/s	81.1	71.2
Time > 5 m/s	75.6	62.7
Time > 6 m/s	62.8	46.5
Time > 7 m/s	50.3	31.0
Time > 8 m/s	38.8	19.4
Time > 9 m/s	28.3	11.1
Time > 10 m/s	18.4	6.1

Table 3: The percentage of the time that the wind exceeds given threshold speeds at the two towers.

Although the wind exceeds necessary thresholds for reasonable proportions of the time there is also a diurnal component to these proportions. These are displayed in figures 1 and 2 where the proportion of time above threshold is plotted against the time of day for each tower.

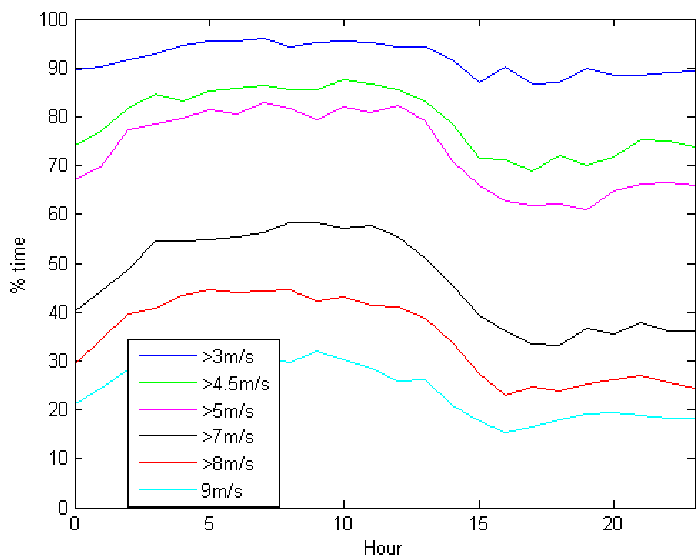

Figure 1: The percentage of the time that the wind exceeds particular thresholds at each hour of the day (UTC) at 93m at Miami.

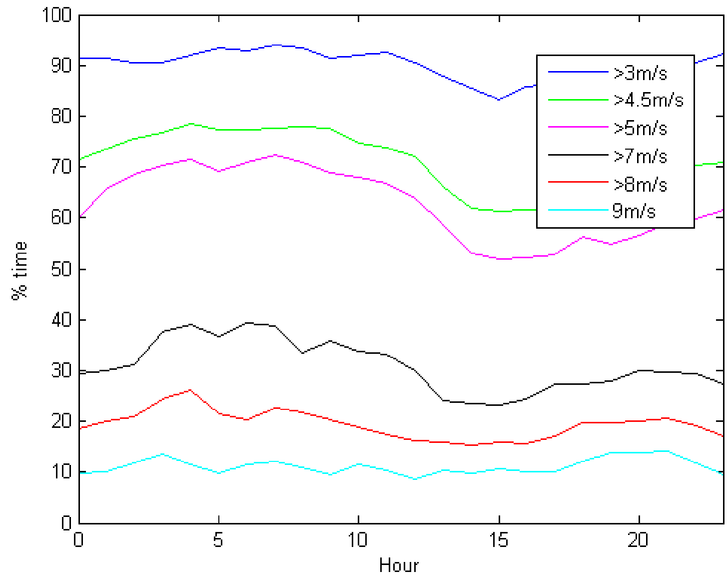

Figure 2: As Figure 1 for Raytown.

The time displayed here is in UTC (GMT) which is 6 hours ahead of Central Time, hence it can be seen that in the overnight hours (4-12 UTC) there is a greater proportion of the time where power could be generated than during the day. This is more noticeable at the Miami site.

The actual frequency distributions of particular wind speeds are shown in figures 3 and 4. It should be noted that all these analyses use the hourly averaged winds to compile the frequency distributions. If the 10-minute wind speeds were used (the shortest averaging time available from the instrumentation) then one would see some higher recorded wind speeds.

This would similarly be the case for observed wind shear. In figures 5 and 6 below are the frequency distributions of observed wind shear parameter (α) at each tower. In this case times when the wind speed was below 3 m/s have been excluded. For shorter periods one would expect to see some more extreme values recorded.

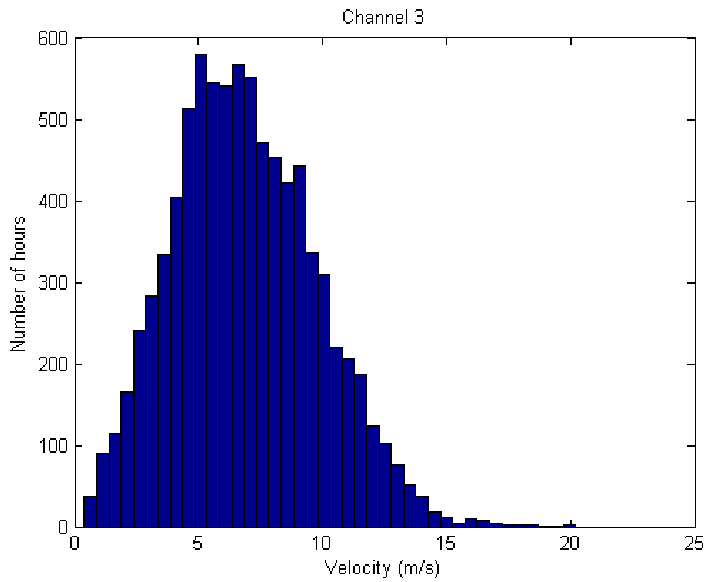

Figure 3: Frequency distribution of wind speeds at 100m at Miami.

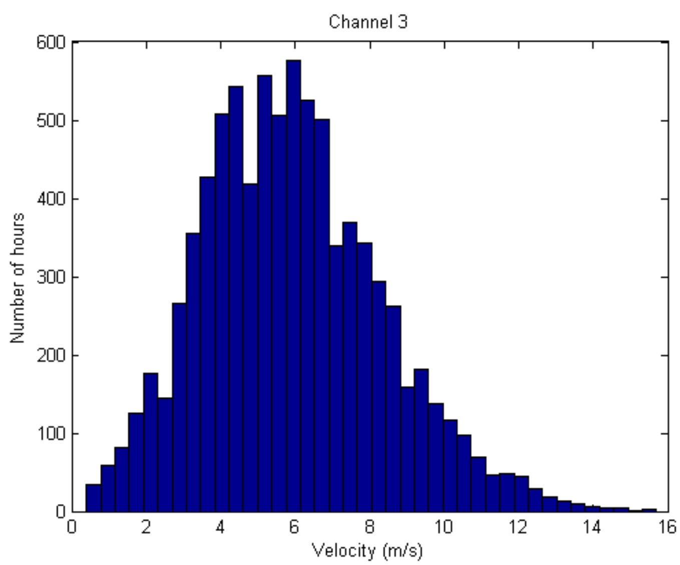

Figure 4: Frequency distribution of wind speeds at 100m at Raytown.

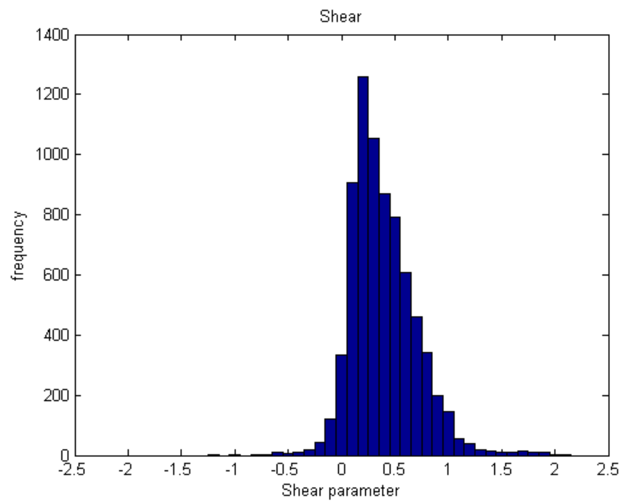

Figure 5: Shear parameter (α) frequency distribution for Miami.

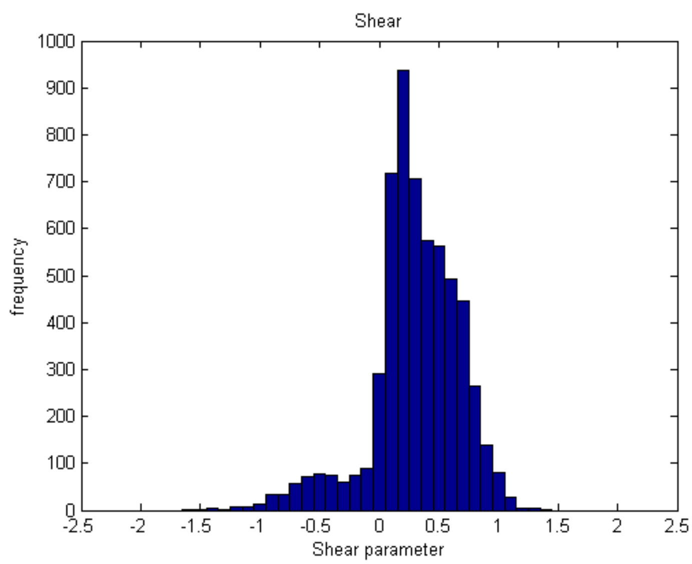

Figure 6: Shear parameter (α) frequency distribution for Raytown.