

## **Grottoes, VA**

### **Project Summary**

As part of Virginia's State-Based Anemometer Loan Program, an anemometer was placed in Grottoes, Virginia to assess the area's wind energy potential. Wind speed and direction were recorded from September 1, 2002 through August 31, 2003. Annual average wind speed during the monitoring period (66 ft. [20m] above ground level) was recorded to be 6.41 mph (2.87 m/s). Wind power density is calculated to be 38.9 W/m<sup>2</sup>.

### **Project Location**

The monitoring equipment was installed on private land in Grottoes, Virginia at an elevation of 1376 feet. The site is located at N 38° 19.52', W 78° 48.59'.

### **Monitoring Equipment**

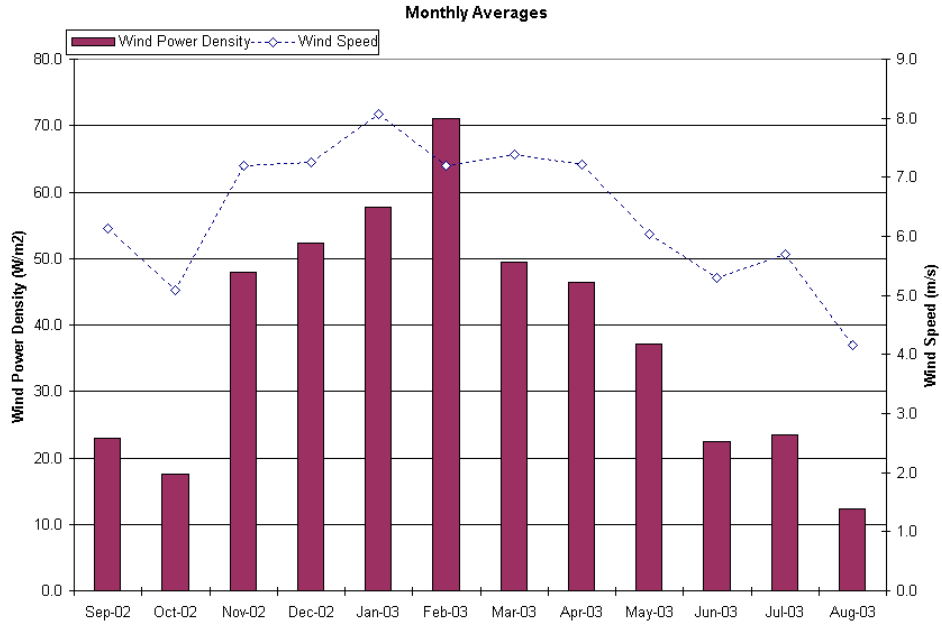
The 20-meter NRG-NOW Systems – Wind Explorer kit includes one tower, one Wind Explorer data logger with shelter box, one #40 Maximum anemometer, one #200P wind direction vane, sensor cabling, one lightning rod with copper ground, and two data plugs.

### **Results**

Average annual wind speed	6.41 mph (2.87 m/s)
Average annual wind power density	38.9 W/m <sup>2</sup>
Month with greatest wind resource	January
Average wind speed during month with greatest resource	8.1 mph
Month with least wind resource	August
Average wind speed during month with least resource	4.2 mph

## Monthly Variation

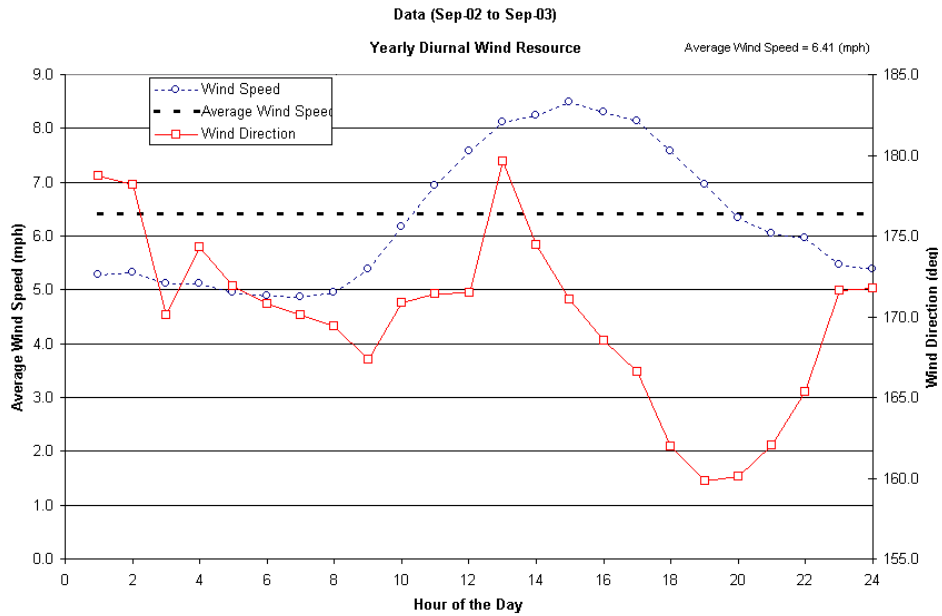
Figure E.2.1 below shows the average monthly wind speed for each month throughout the recorded year. Above average months occur during late fall, winter, and early spring, while below average months occur during summer.



**Figure E.2.1.** Monthly average wind speeds and power densities throughout the year.

## Diurnal Variation

Figure E.2.2 shows how wind speeds vary on an hourly basis. Stronger winds are more prevalent during afternoon and early evening hours. Slower winds more often exist after midnight and during sunrise.



**Figure E.2.2.** Average hourly wind speeds and directions throughout the year.

### Monthly Diurnal Variations

Figure E.2.3 shows the diurnal (hourly) variations of the wind speed over each month. The trends of each month closely follow one another.

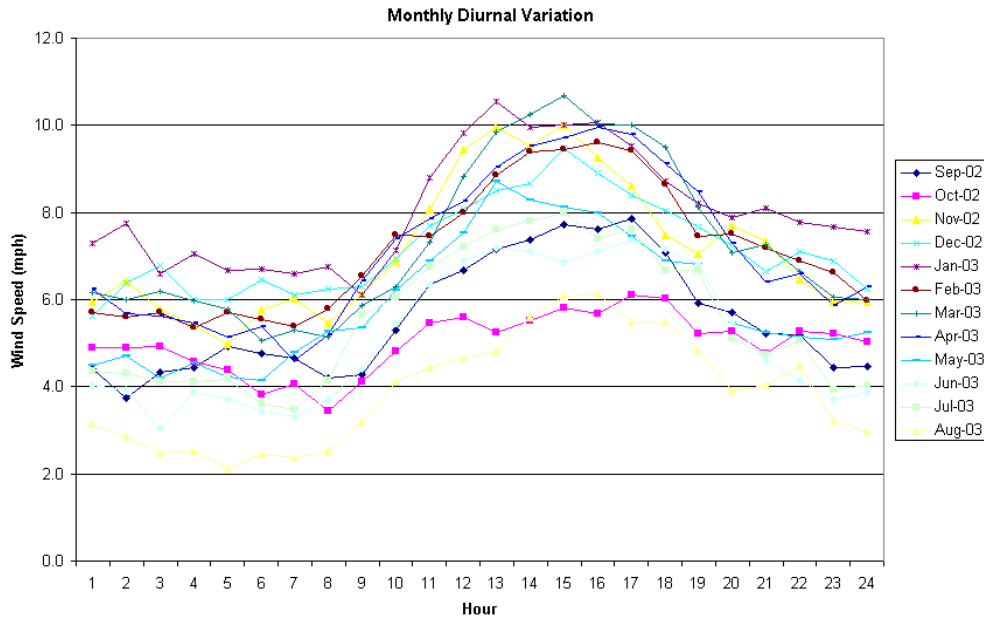


Figure E.2.3. Average hourly wind speeds for each month

### Wind Speed Histogram

Figure E.2.4 shows the occurrence in number of hours that each wind speed occurs. Typically this falls under what is called the Weibull distribution, with a high peak early, and a tailing off at higher wind speeds.

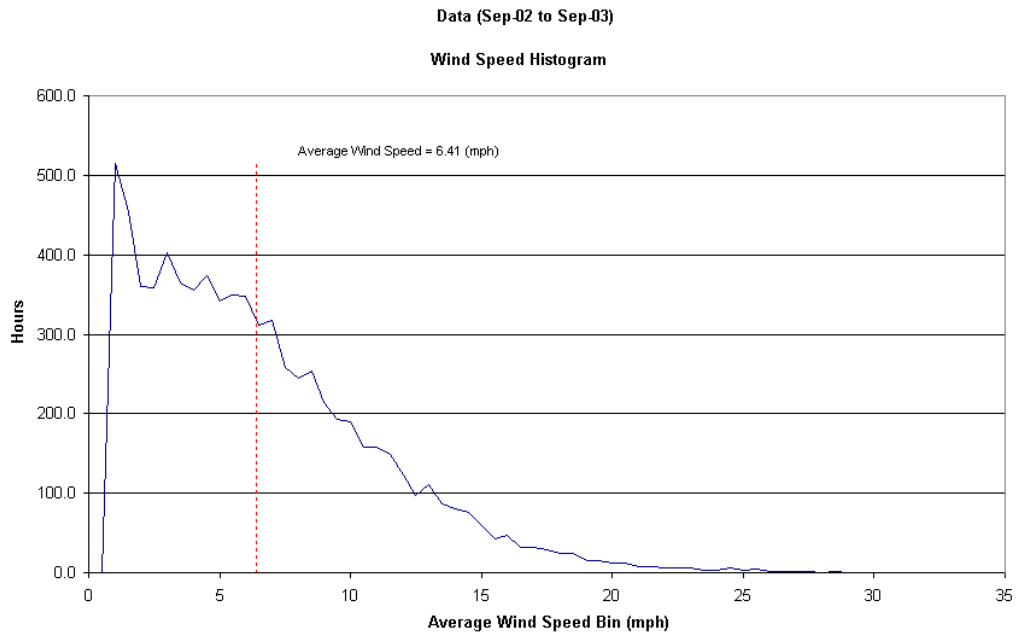


Figure E.2.4. Wind speed frequency over the year by # of hours

### Wind Speed and Direction Trace

Figure E.2.5 shows the wind speed and wind direction reading for every ten-minute average over the course of the data. The wind speed data is the blue line, and the directional data are the red lines.

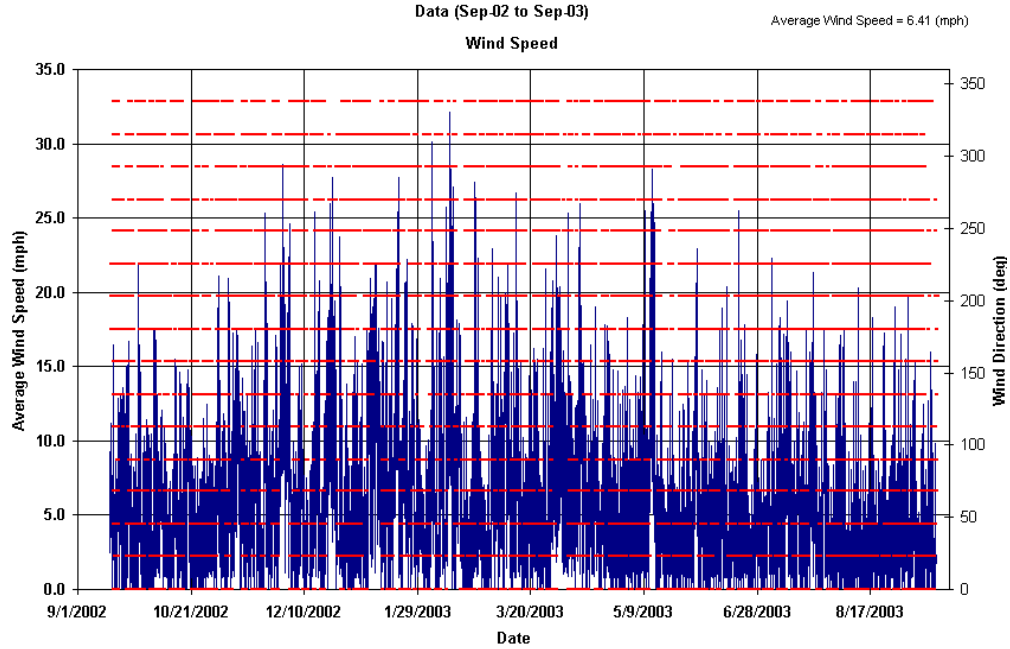


Figure E.2.5. Wind speed and direction readings throughout the year

### Wind Daily Averages

Figure E.2.6 shows the average wind speed and direction by day of the month. Notice there is no particular trend here.

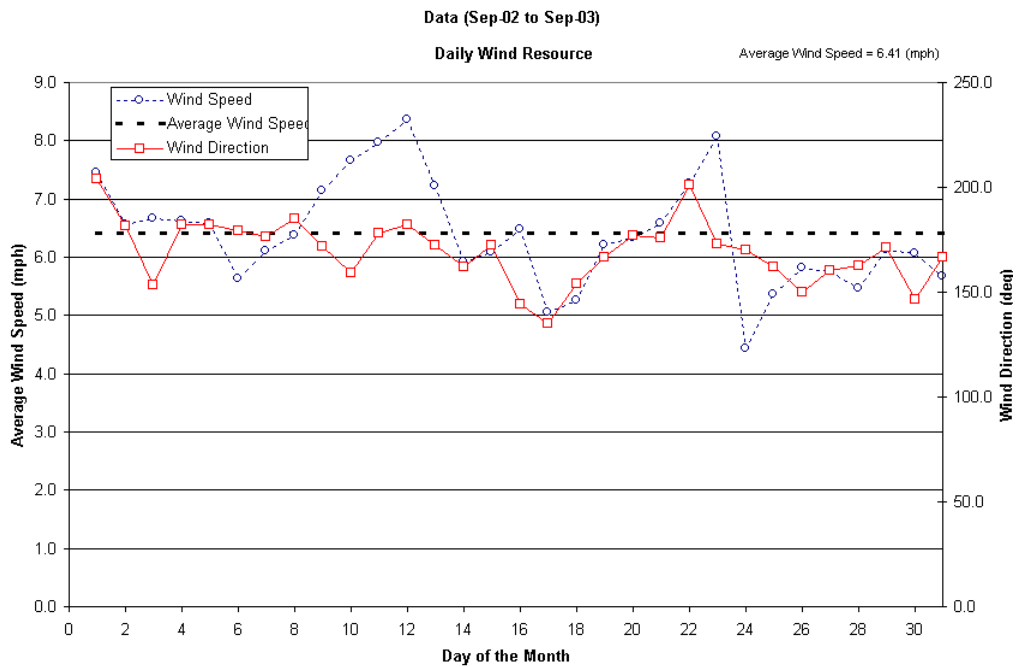


Figure E.2.6. Wind speed and direction averages by day of the month

### Wind Speed Occurrence by Direction

Figure E.2.7 displays the average wind speed for each direction the wind comes from. It also shows the percent of time in that direction bin. For this site the higher wind speeds came from the west.

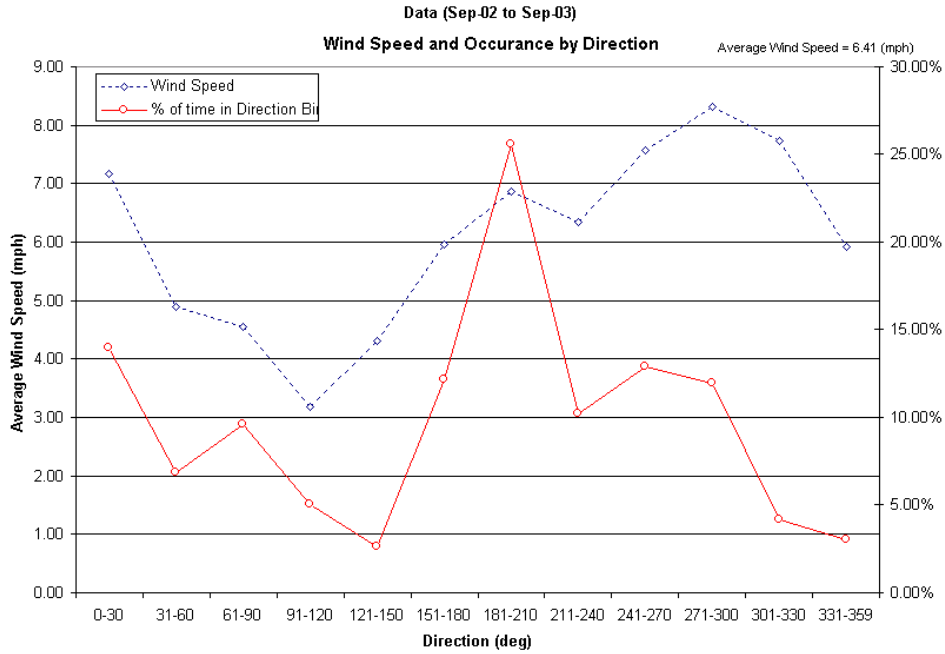


Figure E.2.7. Average wind speed for each direction bin and % time in that bin

### Frequency Wind Rose

Figure E.2.8 displays a frequency wind rose. It can be seen that the majority of the wind come from the south-southwest direction.

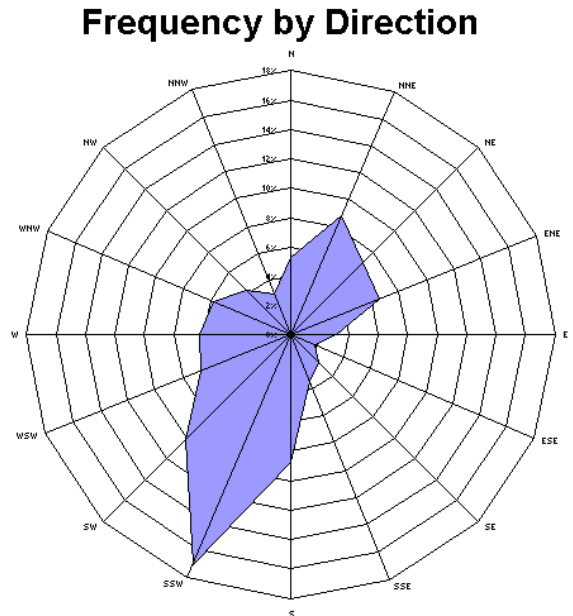
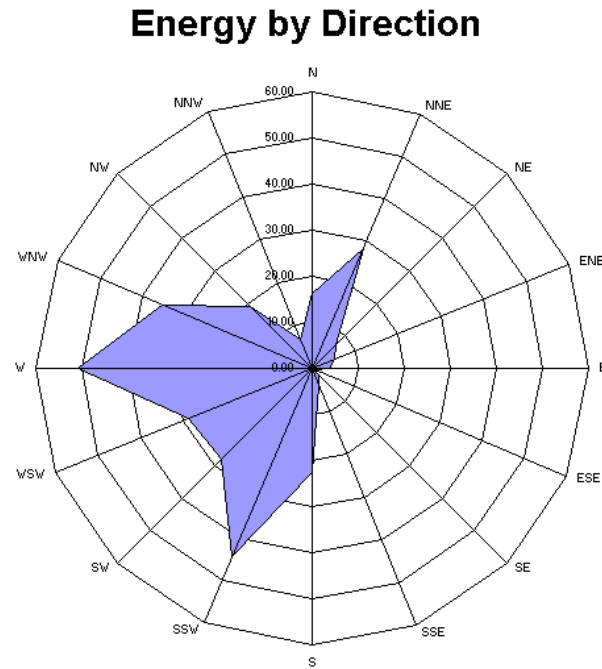


Figure E.2.8. Wind rose displaying wind direction frequency

## Energy Rose

Figure E.2.9 is an energy wind rose, showing the number of kWh/m<sup>2</sup> available from 16 compass-point directions. The majority of energy comes from the west and south-southwest. This is due to the high wind speeds from the west and the southwest due the frequency of occurrence.



**Figure E.2.9.** Energy wind rose with units in kWh/m<sup>2</sup>.