WIND MEASUREMENTS IN REXBURG

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Over the past decade, there has been growing interest in the United States to expand our use of renewable energy. This interest has been motivated by a number of factors, including concerns about global warming and volatile oil and gas prices. During the past decade, the wind industry has seen consistent double-digit annual growth. 2008 was a record year, with the wind power generating capacity in the United States increasing by 50 percent. This growth is expected to continue during the next decade with a number of states passing renewable energy standards which mandate that a certain amount of energy (typically 20 percent) must come from renewable sources.

The Idaho National Laboratory (INL) has taken the lead in assessing the wind resource potential in Idaho, with particular emphasis on sites in the Snake River Valley. Scientists at BYU–Idaho have been involved in this effort and have made wind speed measurements in the Rexburg area. The purpose of this paper is to report some of these measurements and discuss the potential use of wind energy around Rexburg.

Background

The driving force behind winds is differential heating. This can occur on global scales as well as local scales. On a global scale, the differential heating occurs because the equatorial latitudes receive more direct solar radiation than the poles. Ignoring the tilt of the Earth's axis as well as the Earth's rotation, the hotter air at the equator would rise and would draw in colder air from the poles and a simple convection cell would be formed. Because of the Earth's rotation, the air at lower altitudes will not flow directly from north to south but will curve to the east or west (depending on the hemisphere). This is referred to as the Coriolis effect. Combining the global convection cell with the Coriolis effect produces the prevailing winds such as the trade winds, westerlies, and easterlies that are dependent on latitude. Most of the United States is at the latitude of the westerlies so the majority of our fronts and winds move from west to east.

Differential heating can also occur on regional and local levels. In coastal regions, the land and water heat up (and cool down) at different rates creating sea breezes. Heating rates are also influenced by topography. For example, mountains and valleys heat up at different rates during the day and night creating canyon winds.

The winds in the Snake River Valley represent an interesting interaction of global, regional, and local effects. On the global scale, there are the prevailing westerlies. On the regional scale, the westerlies are effectively channeled by the unique topography of the Snake River Valley. On a local scale, there are canyon winds that create diurnal changes in both wind speed and wind direction.[1]

Wind in the United States

Figure 1 shows a map of the wind resources in the United States.[2] The map was constructed by the National Renewable Energy Laboratory (NREL). The wind potential is based on the average wind speed at a height of 50 meters (a common hub height for wind turbines). The map shows that some of the best winds in the United States (and also in the world) are found in the plain states. There are ample winds in the plain states to meet all of the current electrical needs of the United States, as shown by a recent analysis by Xi Lu et al.[3] One of the challenges this country faces is to construct an updated and modernized electrical grid that can be used to transmit this potential source of electricity from the plain states to the population centers in the Midwest and along the east and west coasts. Although not as extensive as the wind resources in the plain states, it is also noted that there are excellent winds along both coasts of the United States as well as the Great Lakes.

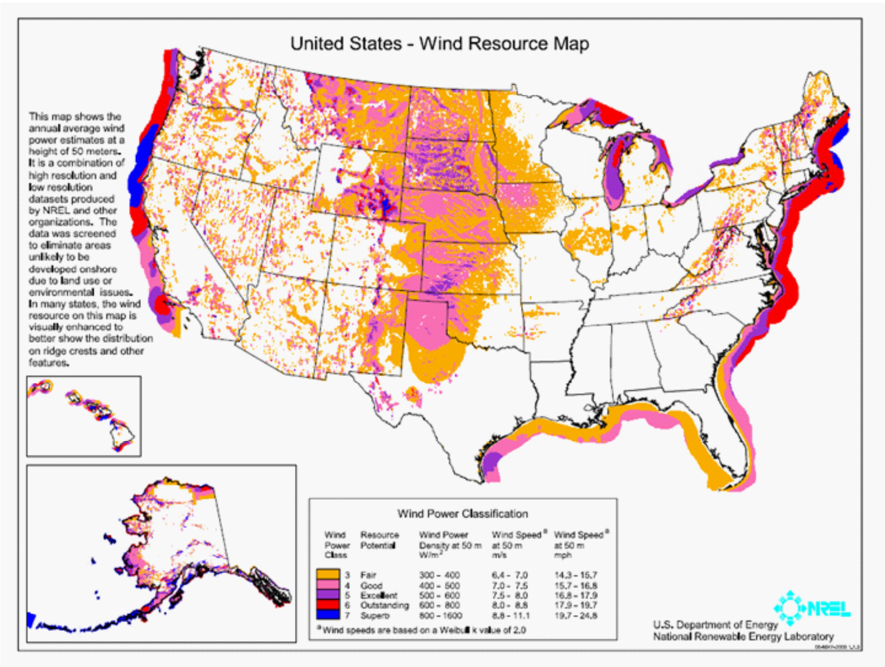

Figure 1 Wind resource map for the United States

From Figure 1, it is observed that the wind resources in Idaho are limited compared to that of the plain states. However, Idaho has pockets of good wind resources that are mainly found along the ridges of the Snake River Valley. To better assess these wind resources, INL has installed approximately forty meteorological towers to collect wind data. Table 1 gives a summary for some of the best locations in Southeastern Idaho. With the exception of Rexburg, all of the sites have Class 5 winds with average wind speeds between 16.8 and 17.9 mph (at a height of 50 meters). These are considered excellent resources.

Table 1 Wind data from sites in Southeastern Idaho

Location	Average Wind Speed (mph) at 50 Meters	Measurement Time (yrs)	Class
American Falls	17.3	1	5
Fort Hall (Wheat Grass Ridge)	18.0	3	5+ to 6-
Idaho Falls (Black Canyon)	17.6	3	5
Rexburg	14.0	2	3

As a result of INL posting this data on the internet for public review, interest in the construction of wind farms has been generated. The first wind farm was installed in Hagerman (near Twin Falls), and this was followed by the Wolverine Creek Wind Farm near Idaho Falls. Currently, there are a number of other wind farm projects for southeastern Idaho in the preliminary stages of development.

Why is the wind speed in Rexburg significantly less than that in the Idaho Falls area? What happens between Idaho Falls and Rexburg to diminish the average wind speed? One important factor is that predominant winds traveling through the Snake River Valley mix with canyon winds from the Palisades area and this mixing tends to diminish the wind speeds.

Monitoring the Wind in Rexburg

Over the past five years, a group at BYU–Idaho has worked with INL to collect wind data in the Rexburg area. The effort began when permission was received from the city of Rexburg to mount wind measuring equipment on the Rexburg water tower. Two years later, in June 2006, a 30-meter tower was installed on the Rexburg Bench. A photo of the tower is shown in Figure 2. At the top of the tower there is an anemometer to measure wind speed and a wind vane to measure wind direction. A data logger, installed at the base of the tower, is used to store the ten minute averages of both wind speed and direction. The maximum gust speeds are also recorded. This tower was operational until May 2009 when a severe wind storm damaged the anemometer.

As an example of the data that has been collected, Figure 3 shows a time-series of the data for December 2008. The data points are 10 minute averages. During the first half of the month, the wind speeds did not exceed 30 mph. The wind speeds increased significantly during the second half of the month. During this time, the jet stream was directly over Rexburg and a series of storms moved in from the Pacific (on an approximately weekly basis), bringing both high winds and significant snowfall. The maximum wind gust (highest two-second wind speed) for the month was 56.4 mph and occurred at 8:14 a.m. on December 13. The overall average wind speed was 13.4 mph for the entire month.

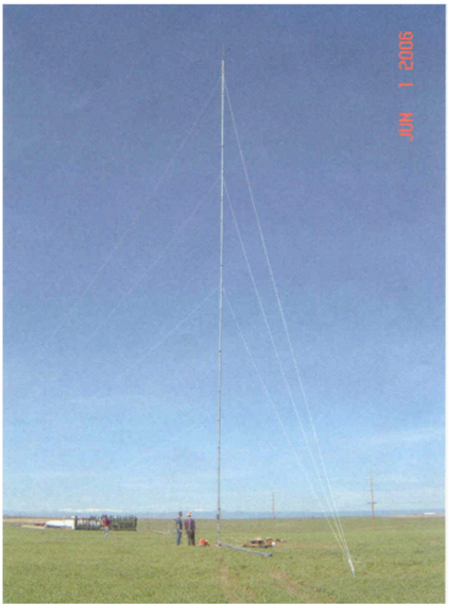

Figure 2 30-meter tower installed on the Rexburg Bench

The variability of the wind, observed in Figure 3, is one of the most significant challenges of large-scale use of the wind as a power source. Other sources of power must be used to meet the energy demand during

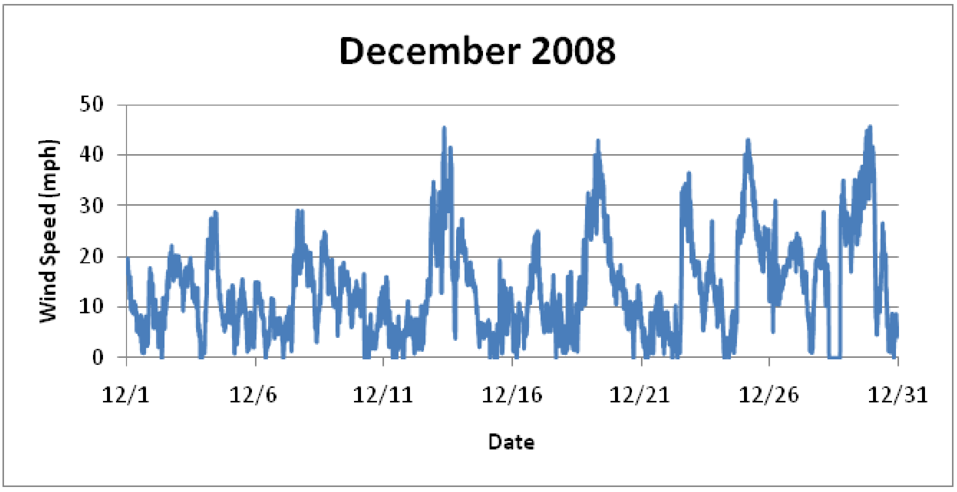

Figure 3 Time-series of wind speed data for the Rexburg Bench site during December 2008

the low-wind periods and quick changes in wind speed (ramps) can cause severe problems to the electrical grid.

The monthly average wind speeds for the Rexburg Bench site are shown in Figure 4. Variations are observed from month to month as well as year to year. This temporal variability is the reason that wind farm developers like to have a minimum of three years of data before putting up large-scale wind turbines. In addition to the temporal variability, there is also spatial variability. Wind speeds can vary significantly over distances as short as hundreds of yards.

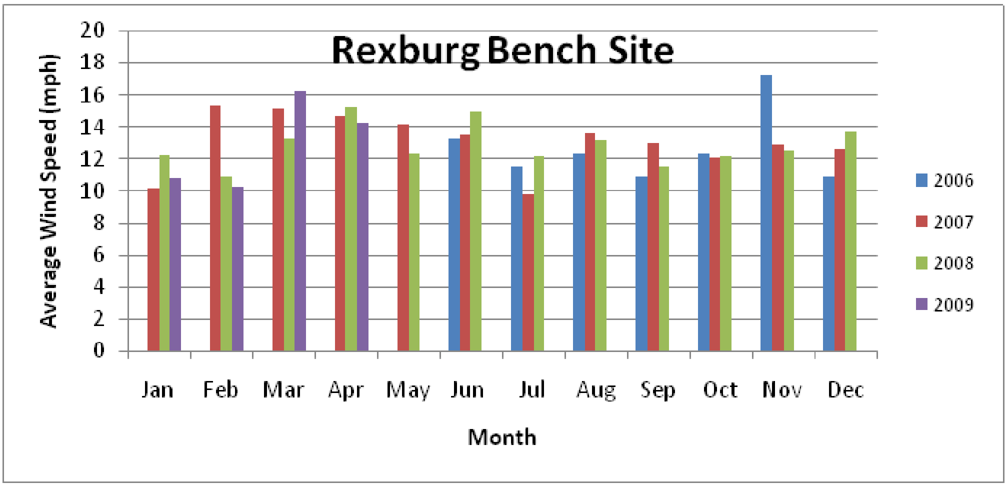

Figure 4 Monthly averages for the Rexburg Bench site

In the Snake River Valley, the winds tend to be the strongest in the spring. The wind speeds start to pick up in March and then April consistently has the highest wind speeds for the year. The wind speeds typically diminish during the summer and then start to pick up during the fall. Over the three-year period, the highest monthly average occurred in November 2006 when the average speed was 17.3 mph.

Figure 5 shows the diurnal wind speed and direction. This plot was constructed using one year of data, and the wind speed and direction data were averaged over the 24 hours of the day. The plot shows a pattern that is seen throughout eastern Idaho. Due to thermal effects in the mountains and valley, the wind dies down in the morning and then picks up again during the afternoon. The direction also shifts during this same time frame. In the morning, it is coming from the SSE direction and then it shifts towards the SSW as the day progresses.

For wind energy production, a very important plot is a histogram of the wind speeds. A plot for the Rexburg Bench site is shown in Figure 6. The histogram gives the distribution of wind speeds using one year of

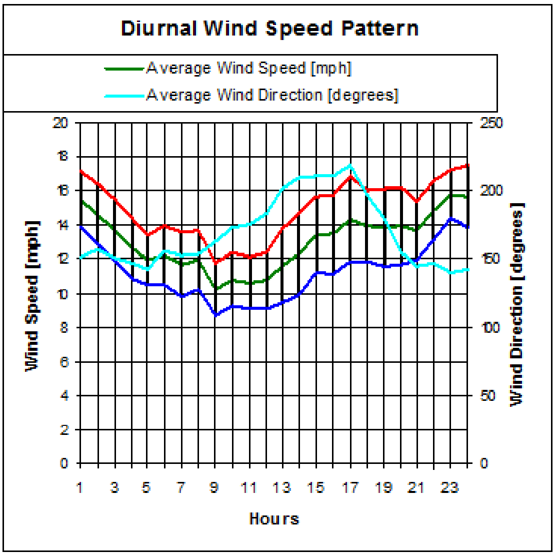

Figure 5 Diurnal wind speed and direction for the Rexburg Bench site

wind data. For the Rexburg Bench site, the most common speed is 11 mph. When this histogram is combined with the power curve for a turbine, the energy output of the turbine can be computed. The available energy at each speed is also shown in Figure 6 for the General Electric 1.5 MW turbine. Speeds of 22 mph are required for the maximum turbine power output of 1.5 MW. This is the reason that the available energy curve peaks at a speed close to 22 mph. Adding together the energy available at the different speeds gives an estimate of the energy production for the site. For the Rexburg Bench site, the estimated annual energy production is 3,763,699 kilowatt-hours. Multiplying this number by the rate at which power is sold to utility companies (typically around 5.5 cents per kilowatt-hour) gives an estimate of the annual revenue from one turbine. For a

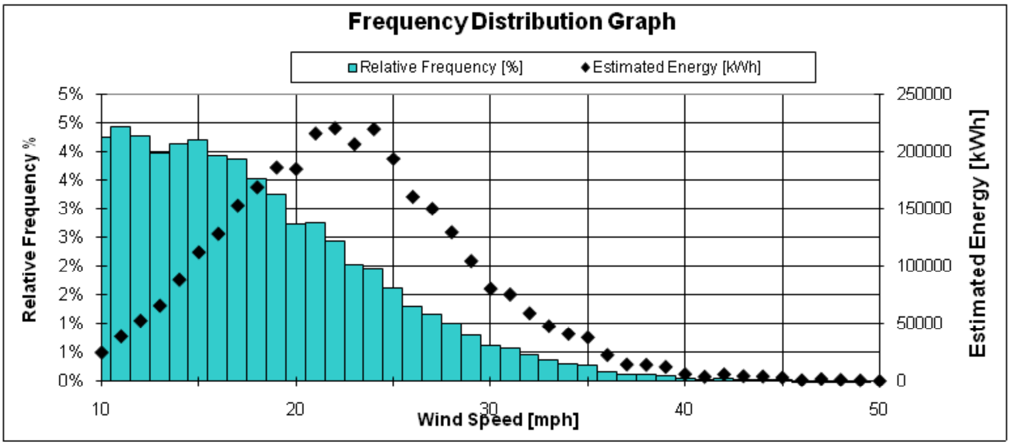

Figure 6 Histogram of wind speeds and estimated energy for Rexburg Bench site

GE 1.5 MW turbine, this would be $207,000 per year. The cost of a GE 1.5 MW turbine (including installation) is approximately $1.75 million.

The final plot, Figure 7, is a wind rose which shows a frequency distribution of the wind directions. The wind rose plot gives information about the most likely direction for the wind. The strong southerly component of the winds in the Rexburg area is evident in the plot with more than 40 percent of the wind coming out of the S and SSW directions. It is observed that the largest percentage of high winds also come out of the S and SSW.

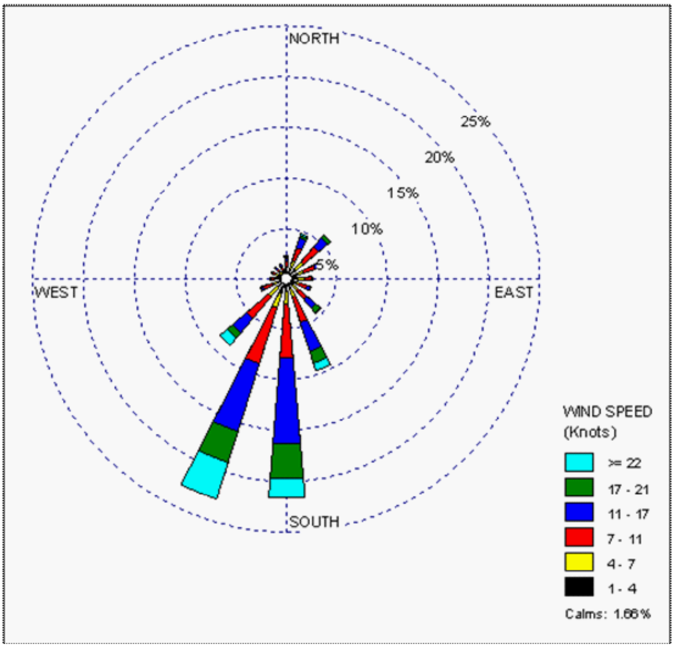

Figure 7 Wind rose for the Rexburg Bench site

Harvesting the Wind in Rexburg

Although the average wind speed in Rexburg is less than that found in other areas in the region, there is still sufficient wind for electrical generation purposes. The slightly lower average wind speeds in this area would result in a longer payback period on a turbine investment. The payback period depends on the size of the turbine, government (state and federal) tax incentives, cost of electricity, and turbine maintenance costs. An approximate comparison would be that the payback time in some of the windiest areas of southeastern Idaho would be about seven years, whereas in the Rexburg area it would be about ten years.

Even with the longer payback period, there is interest in establishing utility-size wind farms in the Rexburg area, and there are projects in preliminary stages of development. There has also been a fair amount of interest in putting up residential turbines. A Skystream 3.7 residential turbine was installed at the BYU–Idaho Livestock Center in November 2008. The data has been used for student and class projects, and there are plans to make the power output data available on the web.

Besides commercial wind farms and residential turbines, there is also the possibility of both community wind projects as well as farm cooperatives. The most important benefit of these types of projects is that the ownership (and revenue) remains in the community that has installed the turbine.

Conclusion

Collection of three years of wind speed data from the Rexburg Bench has made it possible to give a preliminary assessment of the wind resource potential for the Rexburg area. Although the average wind speed at one site on the Rexburg Bench is lower than some areas in southeastern Idaho, there is still sufficient wind for both residential and commercial energy generation. In the future, further wind data collection will be required if this renewable resource is going to be properly utilized and managed in our community.

Notes

1 Jebb Q. Stewart et al., "A Climatological Study of Thermally Driven Wind Systems of the U.S. Intermountain West," Bulletin of the American Meteorological Society 83, no. 5 (2002): 699-708.

2 Wind Powering America, "Wind Resource Maps," U.S. Department of Energy, http://www.windpoweringamerica.gov/wind_maps.asp.

3 Xi Lu, Michael B. McElroy, and Juhu Kiviluoma, "Global Potential for Wind-generated Electricity," Proceedings of the National Academy of Science 106, no 27 (2009): 10933-10938.