Residential Wind Generator Efficiency

David Sweetman (2006)

One of the difficulties facing any homeowner installing renewable energy at their residence is to understand and predict how much energy will actually be produced by the system. Most people are quite leery of advertising (caveat emptor), in many cases for quite valid reasons. In addition to typical marketing hyperbole, there are often many technical and environmental factors that complicate obtaining a usable estimate of actual usable energy.

I have had a Southwest Windpower residential Whisper 175 (or predecessor) wind generator since 1997 (see Home Power issue #86 on the Solar 7 CD). Although there have been a variety of problems with the wind generator, some because of initial design and, at least one, through an error on my part, the wind generator has produced power for almost all of the last 9 years. In 1994, I installed a Davis Instruments Vantage Pro system, with the sensors on the same tower as the wind generator. This has allowed me to obtain actual input data, e.g., wind speed, temperature, to compare with actual output data, e.g., AC kWh produced.

So, the question is: does the Whisper 175 really produce as expected?? The short answer is: yes. The following will summarize the details.

Unfortunately, there was no readily available power prediction equation for the expected power output of the wind generator; however, there was a marketing curve. I (well the Excel spreadsheet) did a 5^{th} order power fit, with an R^2 (correlation coefficient) of over 99%. A 5^{th} order equation was chosen to account for the cubic relationship for power as a function of wind speed and that there are two separate governing mechanisms to protect the wind generator as high wind speeds.

The power produced from the wind generator is not only a function of wind speed, but also of air density. Wind generator power projections are given at sea level; we live in the high desert, so the power prediction equation has to include the effects of altitude and temperature. Since our temperature can vary up to 50°F per day, the temperature correction factor is important. Our altitude alone reduces the output for a given wind speed by over 15%. Additionally, the turn on wind speed of the wind generator will be higher than at sea level, by at least 15%.

There are also conversion efficiencies to transfer the wild 3-phase AC output of the wind generator to single-phase 60 Hz AC suitable for use and selling to the grid. Southwest Windpower predicts an 85% efficiency for the high voltage transformers and rectifiers to convert to DC (nominal 48 volts) and there is a 90% efficiency for the inverter, including the loss for the constant battery charging.

The equation to predict the output is:

If the wind speed is > 9.9 mph, then the predicted power is (where mph = the actual wind mph) = 5.937638832 – (1.380590935*mph) + (0.114976293*mph^2) – (0.003633246*mph^3) + (0.0000473948*mph^4) – (0.000000205255*mph^5)

The following table summarizes results for most of the month of March 2006. Although one month is not necessarily reflective of the entire year in terms of predicting total output, there are more than enough readings (over 1300 wind speed and temperature) to validate the efficacy of the prediction methodology. There is an attached spread sheet that includes all readings and equations, should one desire to review.

	Wind Speed (mph)	Temperature (°F)	Temperature Correction Factor		Prediction No Correction	Prediction With Correction
Average	10.5	38.7	1.031	AC kWh predicted	518.1	337.2
Standard Deviation	7.7	10.6	1.035	AC kWh actual	327.8	327.8
				Prediction accuracy	63.3%	97.2%

As one can readily see, there is a significant difference between the accuracies of the predictions, with and without the correction factors. With the correction factors properly calculated and accounted for, the wind generator produces very close to what should be expected. If one does not account for the correction factors, one will not have a realistic prediction of the actual output.

References:

Southwest Windpower Whisper 175 Data Sheet
http://www.windenergy.com/Whisper_500_Spec_Sheet.pdf
Note, the 175 is now called the 500, but close enough.

Wind Power, Paul Gipe, Chelsea Green Publishing Co., 2004