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Wind Charged Plug-In Hybrid Electric Vehicle

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Abstract

With the emergence of electric vehicles (EVs), hybrid vehicles (HVs) and plug-in hybrid electric vehicles (PHEVs) from a variety of automotive manufacturers, the electrical grid will need to meet new challenges in supplying the electricity required to charge these vehicles. To help supply the electricity needed by these vehicles, we compared the electricity consumption of a modified Toyota Prius (PHEV) and the output of a small residential wind turbine over the course of one year. Our research seeks to determine whether a small residential wind turbine can supply the necessary electricity demanded by the PHEV annually.

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Introduction

As small wind turbine research & development continues to reduce capital expense and increase generation efficiency, more homeowners and small businesses will begin to utilize wind as an alternative source of energy. The growing population of electric vehicles (EVs) will increase electrical demand, especially at night. This added load will increase overall power demand and increase the renewable energy projects required to meet upcoming renewable portfolio standards. Transformers require the lighter off-peak (night) load to cool down. Utility providers may view this added nighttime demand as a problem as it may increase the load to the point where the transformers cannot sufficiently cool off. As a means of offsetting the additional energy required to recharge the electric vehicles, our study compares the energy requirements of our own PHEV along with the electricity generation of a Southwest Windpower Skystream 3.7 wind turbine, installed at the College of Engineering and Applied Science at Western Michigan University.

PHEV Information

Our PHEV, a modified 2004 Toyota Prius, uses the Hymotion A123 L5 Lithium Ion Battery Pack. The battery has a capacity of 5 kWh, a maximum recharge time of 5.5 hours (at 120Vac) and can provide a nominal driving range of up to 20-25 miles on electricity. During our study, the Prius traveled a total of 16,195 miles, of which, 5,449 miles (34%) were in electric PHEV mode.

Wind Turbine Information

The wind turbine used for the project is a Skystream 3.7, manufactured by Southwest Windpower. The turbine has a rated capacity of 1.8 kW, sits atop a 45 ft pole, and has a 12ft blade diameter. In our current geographic area, southwest Michigan, the wind turbine produces approximately 1200 kWh – 1500 kWh per year. (From December 2008 – December 2009 it produced 1442 kWh.)

Discussion

To address our initial question on whether or not a small residential wind turbine had the capability to provide adequate electricity (annually) for the PHEV, we would require the ability to monitor and record the daily output of the wind turbine. The wind turbine came with adequate hardware and software capable of the necessary data acquisition. However, we installed an additional monitoring device, the Shark Meter, on both the wind turbine and near the PHEVs parking space so that we may compare the data using similar systems.

Wind Availability

The availability of wind varies considerably based on geographical location. The wind turbine we used is located at the College of Engineering and Applied Science at Western Michigan

University in Southwest Michigan. Throughout southwest Michigan, mid-level wind maps show our location at 50m to be approximately rank 1 and rank 2 levels for wind energy generation. At rank 1 (white) and rank 2 (brown) locations, wind speeds reach up to 5.6 m/s and 6.4 m/s respectively.

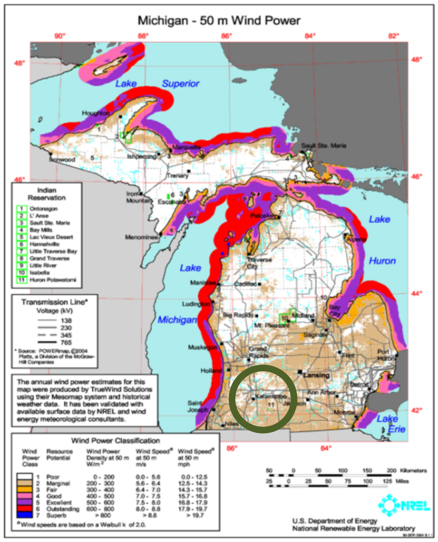

Figure 1: WMU wind turbine located in Kalamazoo, MI as noted on the above map

Annual Wind Electricity Generation

The wind turbines ability to produce electricity is not only related to geographic location and wind availability, but also season and time of year. In the late spring, early fall, and summer months, electricity production tends to be fairly low. Exceptions do occur however. The colder months, starting in early December and lasting through March is when peak production time tends to occur. During the project year (December 2008 – December 2009), we generated 1442 kWh which was able to provide enough electricity for the Prius, which required 1352 for the entire year with a 90 kWh surplus.

As shown below in ***Figure 2***, the wind turbine at WMU was capable of generating sufficient electricity to offset the electricity consumption of the PHEV for our project year. The first three bars in Figure 2 represent the electric generation, consumption, and surplus associated with only driving the PHEV to work (WMU) and back home. The last three bars represent the electric generation, consumption, and surplus associated with driving to all locations (within the limitations of the battery).

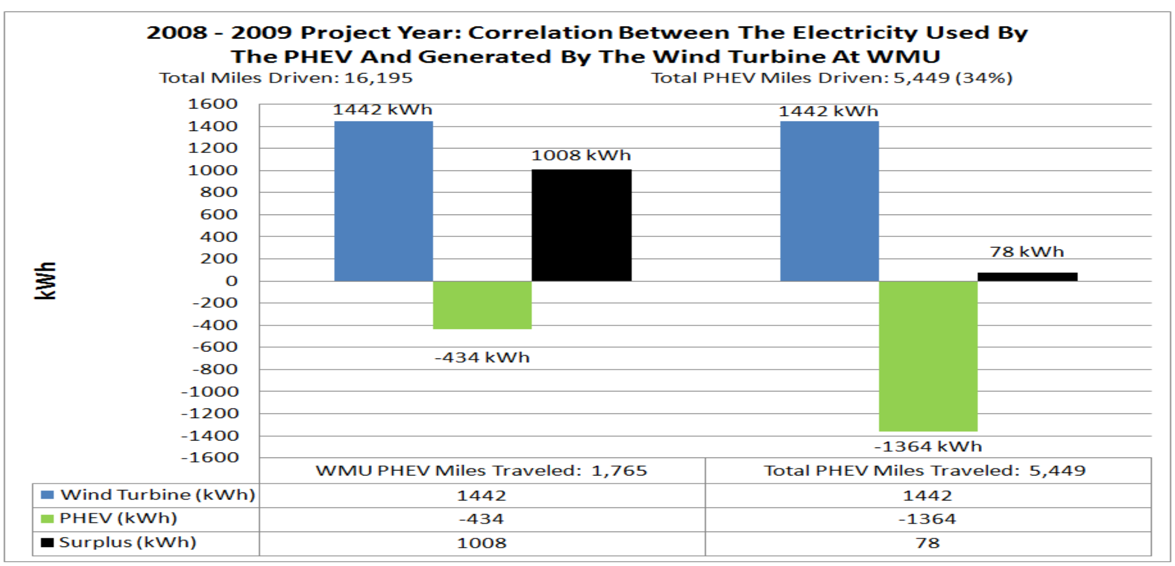

Figure 2

Seasonal Wind Electricity Generation

The electricity produced by wind power changes on an instantaneous level over the course of days, weeks, months and years. During the study, we monitored seasonal wind power readings and comparing them to the consumption needs of the PHEV. Seasonally, the colder winter months more commonly provide the greatest levels of electricity generation while the warmer summer months commonly produce the least electricity throughout the course of the year (as noted in ***Figures 3 & 4*** respectively).

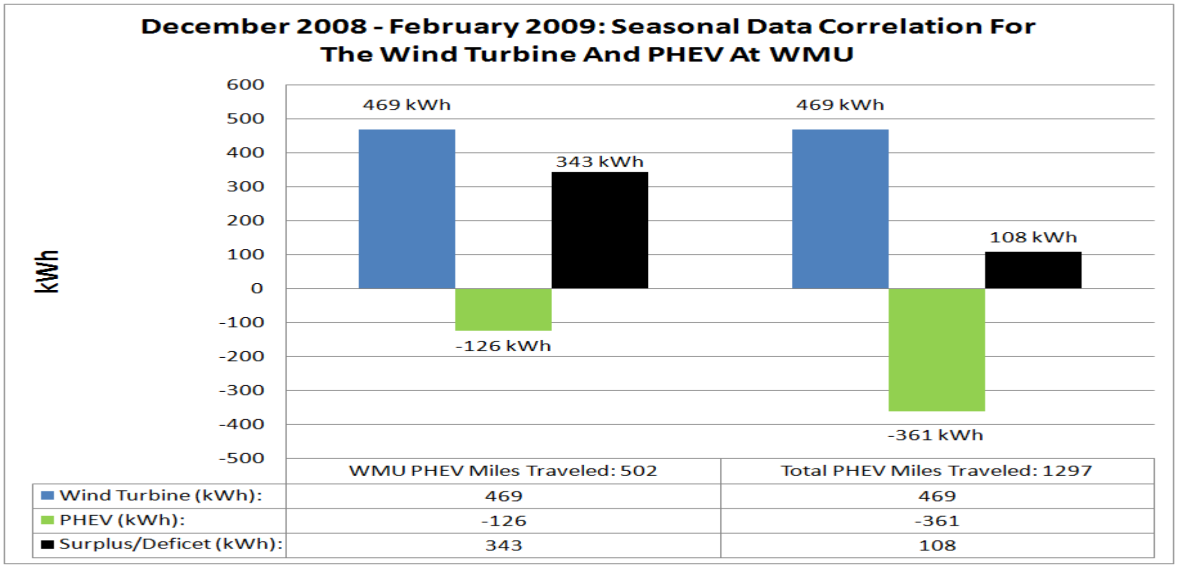

Figure 3: Winter Season

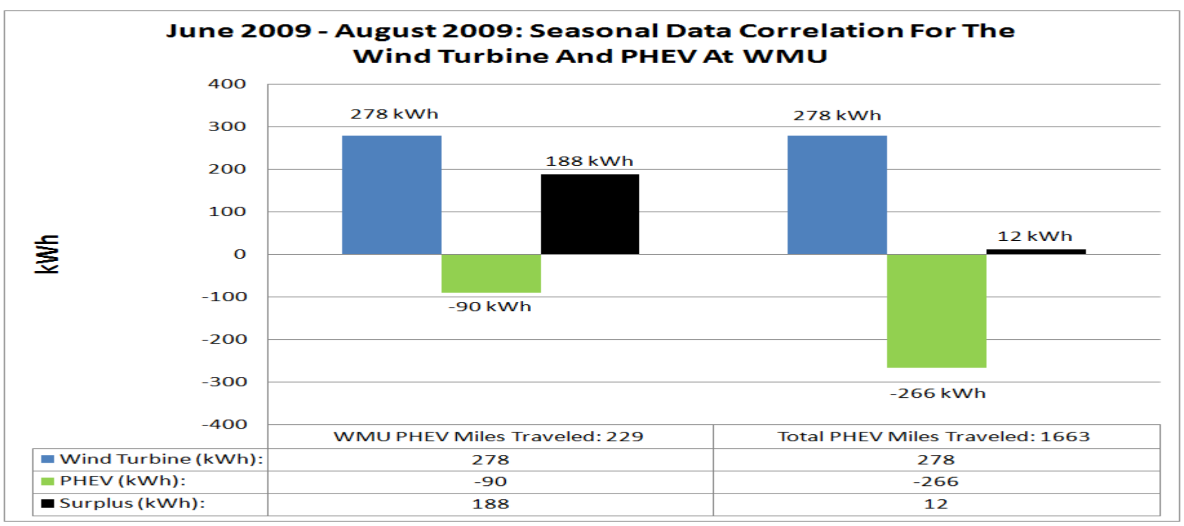

Figure 4: Summer Season

Conclusions

The study concluded that the wind turbine used is capable of producing adequate electricity to offset the electrical consumption of the PHEV on an annual level. However, on a daily, monthly, or even seasonal level, the wind power captured may have been insufficient to provide adequate electricity to the PHEV as needed at times. Similar studies performed in greater wind power regions could have the potential to produce results capable of directly charging the PHEV without a grid tie-in.

References

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