Generating Electricity From Highway Traffic

Matthew Penne and Wei Qiao

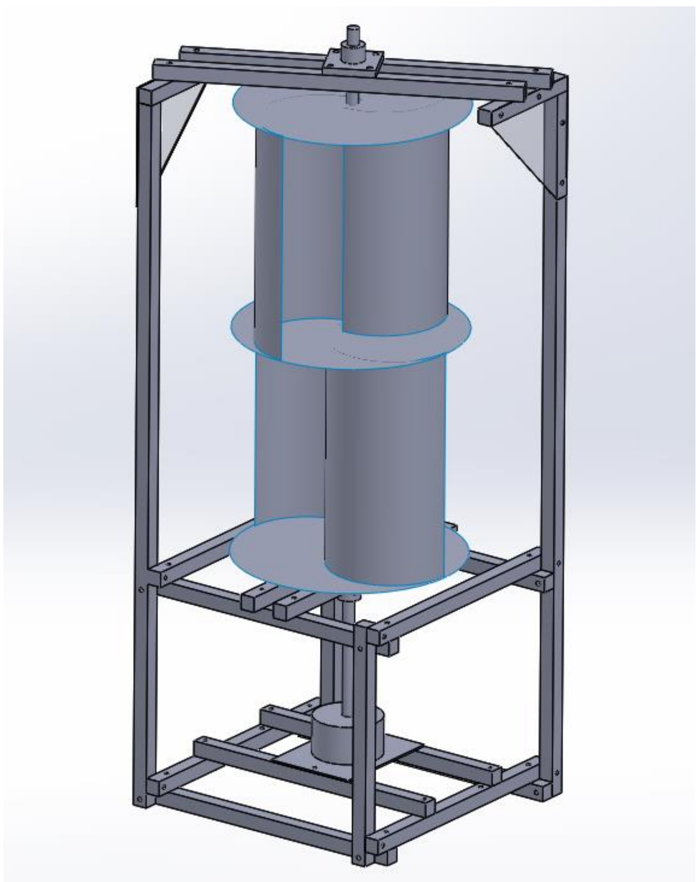
Power and Energy Systems Lab — Department of Electrical and Computer Engineering

Abstract/Introduction

The intention of this project was to test if a vehicle travelling at high speeds would produce significant airspeeds at a reasonable distance away from the vehicle. If the air speeds were found to be sufficient, a machine would be designed to capture the wind and convert it to electricity.

Wind speeds from greater than four feet away were considered to adhere to safety standards provided by the Federal Highway Administration.

Wind Turbine Design



Upon analysis of the data, the area from four to six feet away from traffic and from one to six feet above the ground were to be the parameters of the turbine.

Several different wind turbine devices were considered for this application. A horizontal axis turbine, a Darrieus style vertical axis wind turbine, and a vibrational style device were eliminated. A Two-Stage Savonius turbine was used, due to its more rigid structure, ability to harness winds from any direction, ability to harness gusts, constant positive torque, and relatively low cost. Despite the low coefficient of performance associated with this design, the Savonius design appears to be the best choice.

A half-scale turbine was designed, assembled, and tested. The turbine itself is made of 20 gauge steel, the framework of one inch steel tubing, and the alternator is a 160 Watt model that was previously used in the lab. The turbine has an aspect ratio of 2 and an overlap ratio of .17. The dimensions of the turbine are 30 inches tall by 15 inches wide.

For such a small application, the steel turbine was determined to be sufficient with the weight being around 12 pounds. A full sized turbine made with this material would weigh more than 75 pounds, so new materials must be considered in the future.

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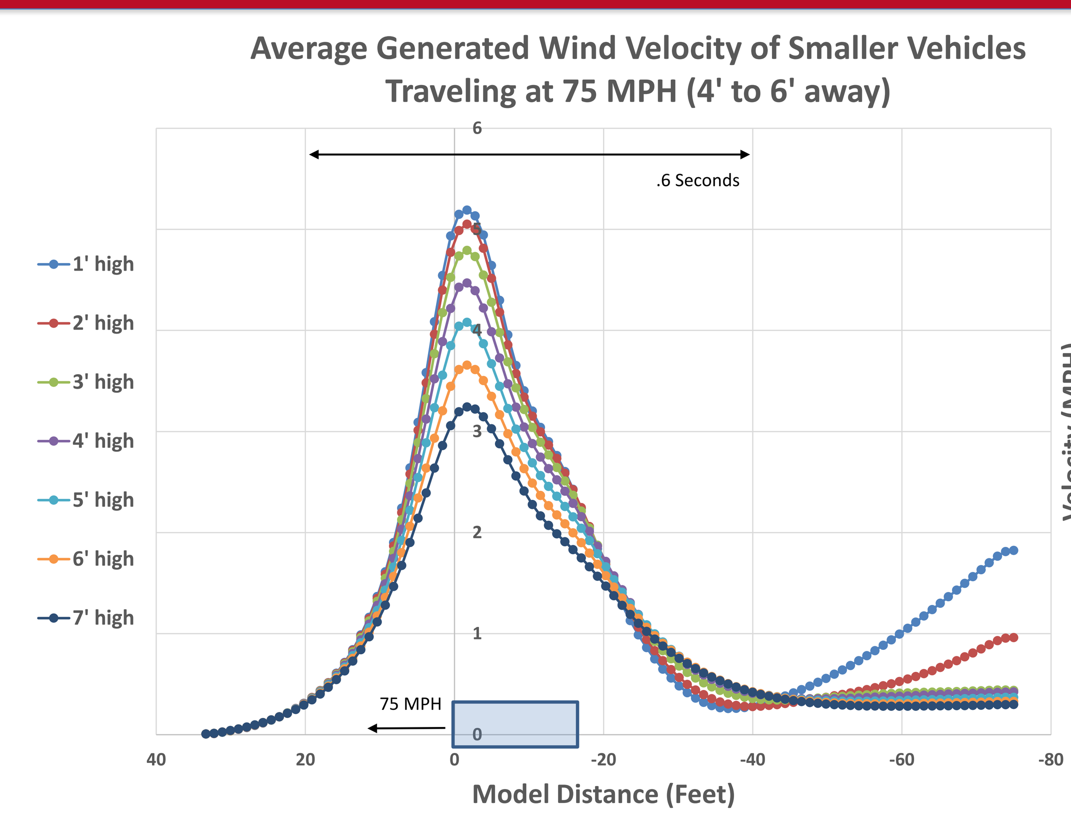
Wind Profiles of High Speed Vehicles

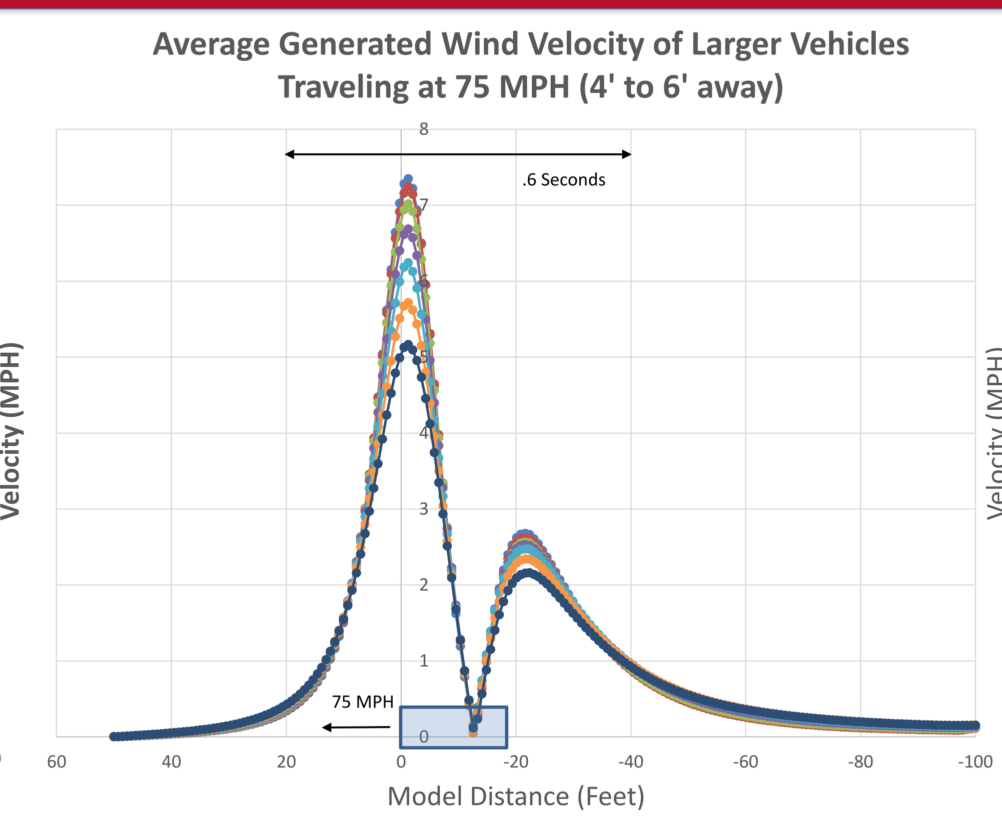
Solidworks Flow Simulator was primarily used for obtaining the wind profiles. Smaller models were confirmed with ANSYS Fluent, but further testing with ANSYS was limited due to restrictions. Values were obtained by using a steady state simulation and averaging values from four, five, and six feet away from the vehicle. The small vehicles models used were a Toyota Corolla and a Honda CR-V, which were then averaged together. The larger vehicles used were a Ford Explorer and a crew cab Chevy Silverado. These models were drawn from isometric images of the vehicles. A 3-D model of a Mercedes Semi with trailer was obtained from grabcad.com.

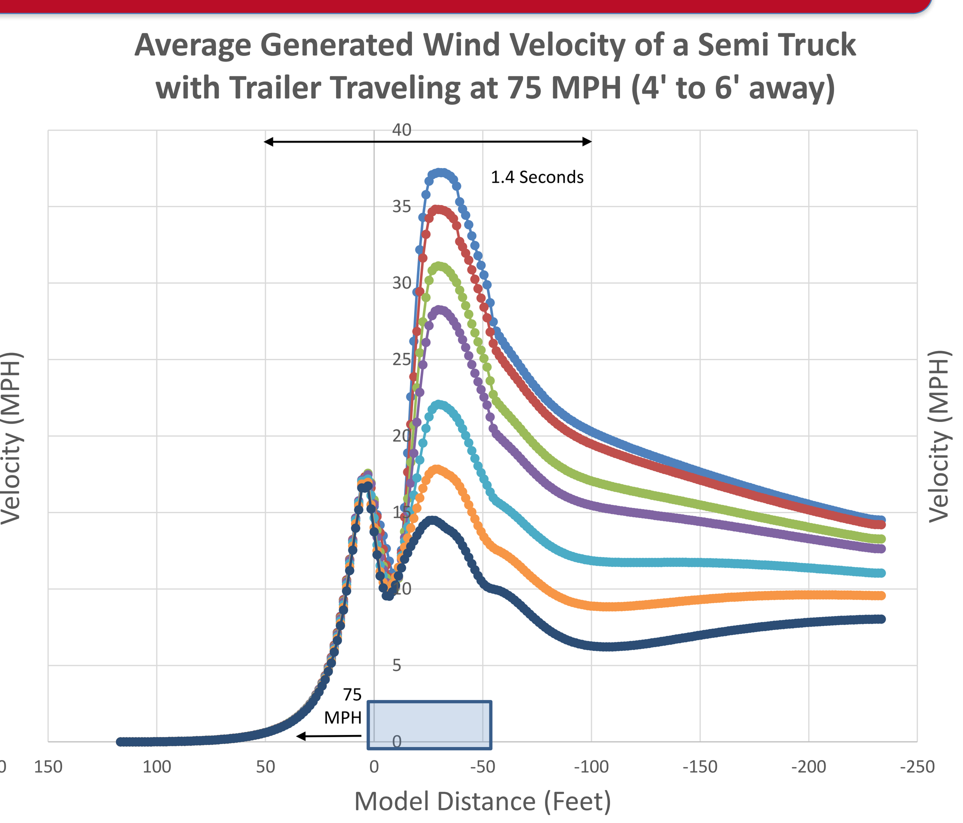
As intuition suggests, larger vehicles produce greater wind speeds and wind speeds increase closer to the vehicle. What is not accurately displayed by these graphs is the rapidly shifting direction of the wind speeds when a vehicle passes. This rapid shifting of wind speeds would not be properly captured by a common horizontal axis wind turbine. As made apparent by the graphs, the wind produced by light-duty vehicles is dwarfed by that produced by semi truck traffic.

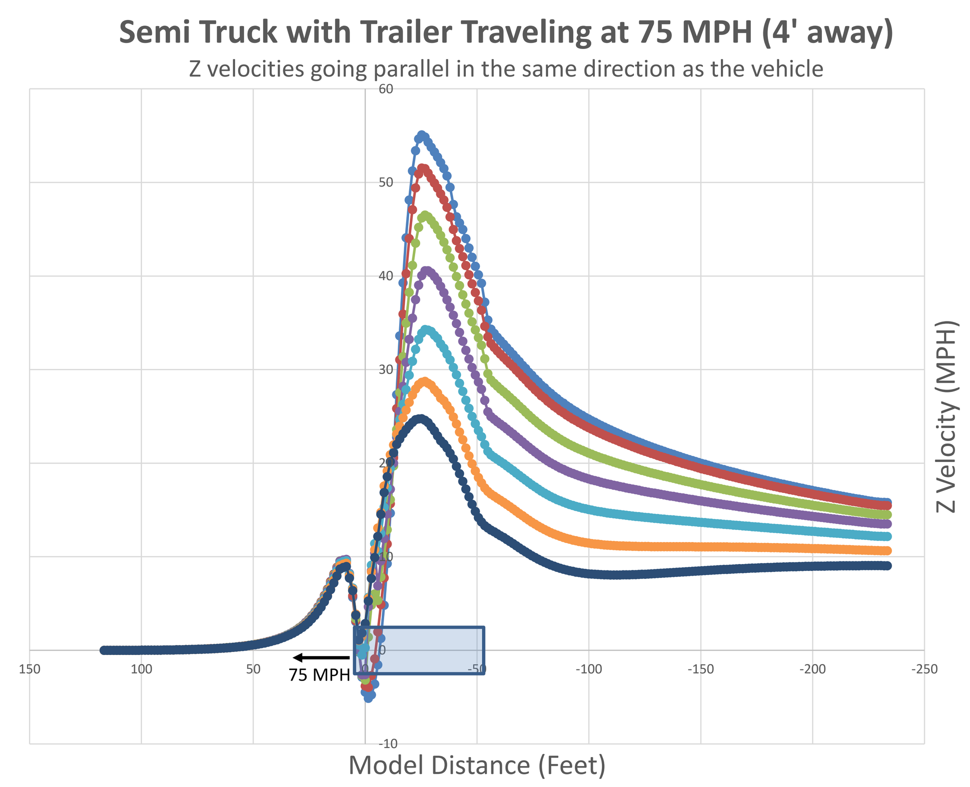
Other notable findings show that a semi truck traveling at 60 MPH also produces significant wind speed at 4 feet away, increasing the applicability of this project.

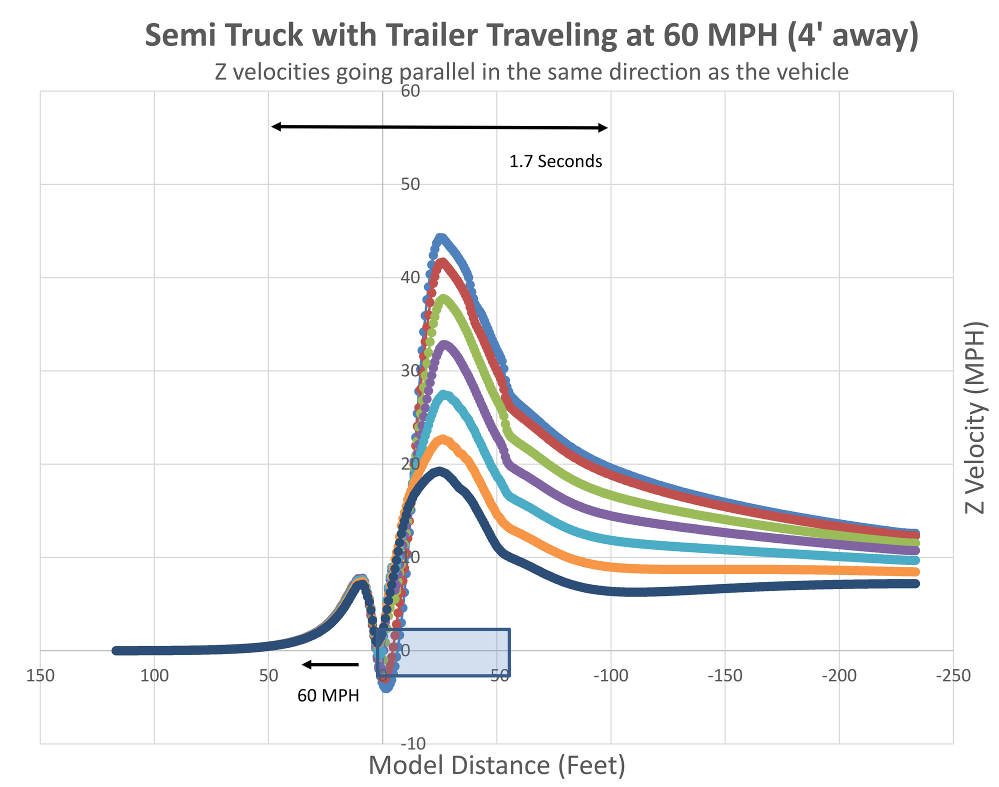
The blue box on the graphs are to give a sense of where the vehicle is in relation to the wind velocities. The lasting wind effects past two body lengths beyond the car are due to ground effects caused by the simulation and would be mitigated by further and better testing. Additionally, the magnitude of wind speeds one foot high would be slightly decreased by a better model.









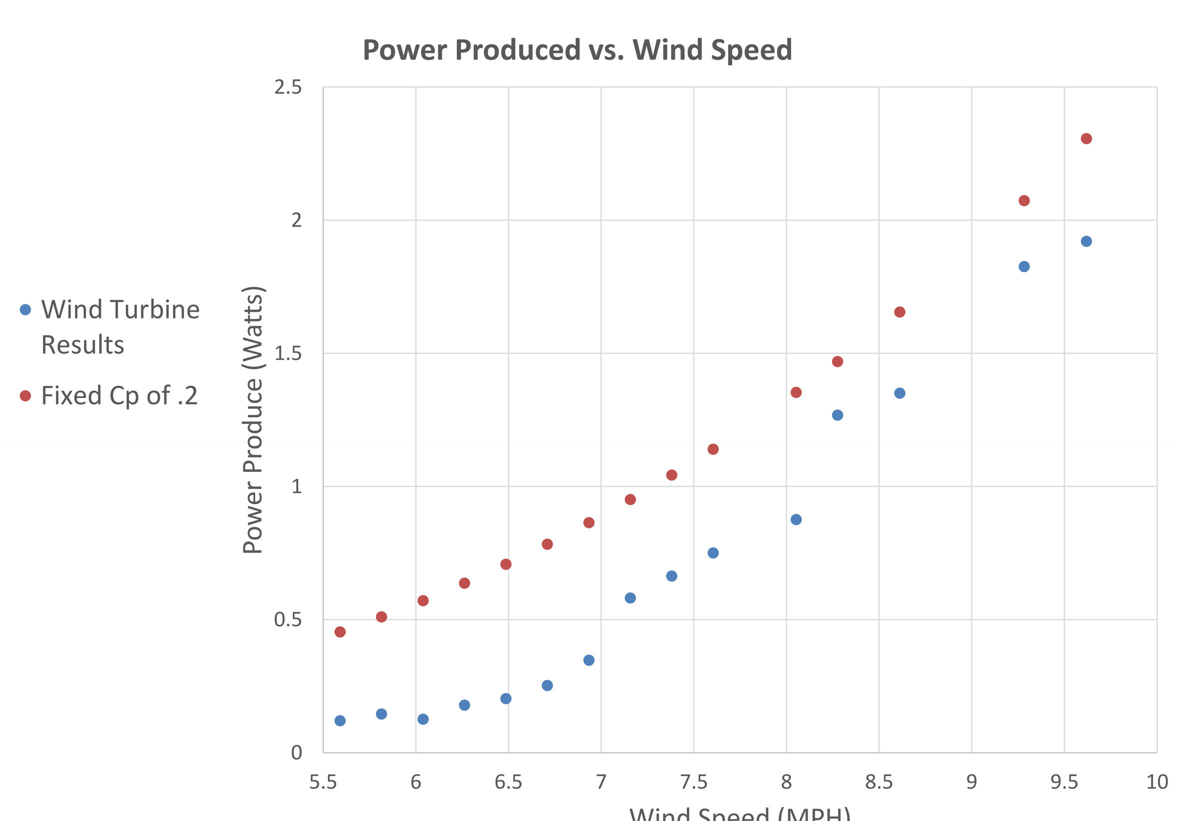


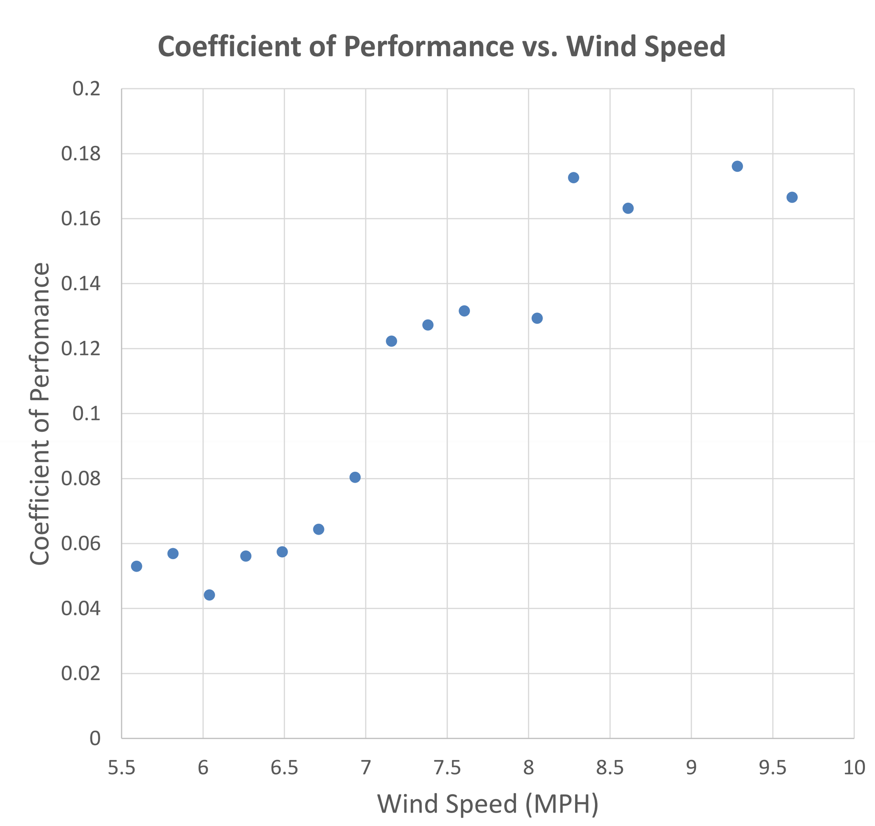
Data From Wind Turbine Testing

The Wind Tunnel in the Power and Energy Systems Lab was used to test the prototype turbine. The alternator was connected to a balanced Wye load of 12.5 ohms. The wind tunnel was able to generate speeds up to 9.6 MPH. The testing of high speed gusts is unable to be produced in the lab with current means, so other methods will be considered in the future.

The turbine was found to start spinning at 5.5 MPH, with RPM increasing rapidly with higher wind speeds.

The Coefficient of Performance (how effectively a turbine converts wind energy into electricity) of a Savonius design is usually around .2, so the rough .17 coefficient obtained is reasonable.





Speed (MPH)	Power Produced (Watts)	Coefficient of Performance	RPM
5.59	0.12	0.05	144
5.82	0.15	0.06	170
6.04	0.13	0.04	180
6.26	0.18	0.06	230
6.49	0.20	0.06	240
6.71	0.25	0.06	280
6.93	0.35	0.08	360
7.16	0.58	0.12	480
7.38	0.66	0.13	540
7.61	0.75	0.13	530
8.05	0.88	0.13	645
8.28	1.27	0.17	700
8.61	1.35	0.16	760
9.28	1.83	0.18	840
9.62	1.92	0.17	1020

Analysis and Conclusion

Using the found data and information taken from the Nebraska Department of Roads, a full sized turbine placed in a good spot on I-80 or similar roadway would produce around 1.8 kWh a day from road traffic alone. With having such a low starting wind speed, additional electricity will be generated by regular winds. Theoretically, winds from different directions will have a compounding effect, but further testing is needed for confirmation. Additionally, vehicle-induced winds will be greater on the positive torque side and lesser on the negative torque side, only increasing efficiency.

With conservative production methods, mindful placement, and limited maintenance, these turbines may prove to be a cost effective source of electricity production.

References and Acknowledgments

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Grabcad.com provided the Semi Truck Model.

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