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Floating Laser Pulse Technology: A Strategy for Great Lakes Hub Height Offshore Wind Assessments

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Floating Laser Pulse Technology: A Strategy for Great Lakes Hub Height Offshore Wind Assessments
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Introduction
The principle purpose of this project is to conduct a wind assessment study of Lake Michigan and to advance the body of knowledge that will allow industry in the Great Lakes region to develop offshore wind power. The project involves the permitting and installation of the first offshore and onshore assessment meteorological (MET) facilities in Michigan's Great Lakes, utilizing Laser Pulse Technology (LPT). In addition to validating the technology, this important research will allow us to analyze the characteristics of offshore wind technologies and their potential for the Great Lakes. A key component of this project is to conduct a comprehensive study of Turbulent Kinetic Energy (TKE) offshore, which will provide valuable insights into the behavior of wind in the offshore environment.

Objective
This is the first study of Turbulent Kinetic Energy (TKE) offshore by a federal agency in the United States. The primary objective of this study is to conduct a comprehensive offshore study of TKE in Lake Michigan. The study will involve the use of advanced meteorological equipment to measure TKE offshore, and the results will be compared to onshore measurements to assess the differences and similarities. The findings of this study will provide valuable information for the development of offshore wind power in the Great Lakes region.

Scope of Work
While valuable lessons can be learned from current offshore wind turbine installations, the Great Lakes area poses particular challenges to the development and deployment of offshore wind power. Due to the unique characteristics of the region, including the presence of strong winds and the variability of the wind resource, the project will involve a comprehensive study of offshore wind energy. The study will involve the deployment of advanced meteorological equipment offshore, including the use of Laser Pulse Technology (LPT) to measure TKE. The project will also involve the collection and analysis of data from onshore meteorological stations to provide a comprehensive picture of offshore wind conditions in the Great Lakes.

Mid-Lake Location
Located 35 miles offshore in 186 feet of water, the research buoy experienced significant storms with sustained winds of 80 mph, gust to 100 mph, and 28-foot seas.

On-Board Equipment
To select the appropriate MET facilities for Lake Michigan, GVSU issued a request for proposals to construct a fixed spar tower equipped with anemometers and other sensors. Two competitive bids were received and the lowest bid was $12 million dollars, well in excess of the funds available. All bids were rejected and a second request for proposals was issued that did not restrict proposals to a fixed spar. Three proposals were received, one for a floating platform, with two for a floating spar buoy. After careful deliberation with the Research Team and negotiations with the proposing vendors, the WindSentinel Buoy was selected because of cost, flexibility of hardware installation, and ease of movement.

The WindSentinel Buoy is a Nomad style platform buoy, 20' long with a 10' beam. The GVSU configuration includes the following equipment:

- **Vindicator Laser Wind Sensor** using laser pulse technology (LPT). The Vindicator can be set to measure wind speed and direction at six different heights or range gates. The GVSU's range gates are set at 75m, 90m, 105m, 125m, 150m, and 175m.
- **Vindicator 35S data controller** that collects over 300 data parameters per second. The new data is filtered and 1 second data is converted to 10 minutes averages for transmission to shore and the project server.
- **Orientation and position system including compass engine and GPS (D)**
- **Data Transmission** is accomplished by use of one to three on board systems; wireless cell phone, internal and external satellite systems.
- **Baseline** includes two small panels, wind turbine, and a back-up generator with a 24 volt 135 amp alternator. A bank of 40 batteries stores the energy. The system is designed to operate without assistance by 6-9 months.
- **Bird and bat FMQ acoustic sensors**
- **Data Logger**, including a directional wave sensor, relative humidity and temperature, water quality monitors, atmospheric pressure, 2 anemometers, water temperature, and AIS system.

Results
The wind rose graphs show the wind speed by direction as well as the percent of time the wind is flowing in the direction shown in Figure 4. The wind resource data is summarized in Table 1. The table and charts below summarize the data collected by the Laser Wind Sensor.

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**EQUIPMENT VALIDATION**

**Pared-4 Analysis for the >6.7m/s, No Enhanced Turbulence Data Set**

**Data Set** | Mean Difference (m/s) | Standard Deviation (m/s) | Coefficient of Variation (%) | Number of Observations | % 95% Confidence Interval
---|---|---|---|---|---
>6.7 m/s no enhanced turbulence | -0.028 | 1.1 | -35 | 65% | 416 | -0.17 | 0.11

The magnitude of the mean difference is less 0.1 m/s. This difference is neither operationally nor statistically significant (p=0.01) as the 95% confidence interval for the true mean difference contains zero. Again, the coefficient of variation is much greater than 1 indicating that the mean difference is due to random variation. Thus, validation evidence is obtained for wind speeds greater than 6.7 m/s and no enhanced turbulence. The correlation coefficient of 65% is due to a few large differences seen at high wind speeds (Figure 5) as would be expected.

**EVIDENCE OF BAT ACTIVITY**

The current Lake Michigan offshore Wind Study is the first systematic assessment of bat and bird activity in offshore areas of Lake Michigan in relation to wind energy development. To the best of our knowledge, these represent the first such recordings made in offshore (“over the horizon”) areas in the Great Lakes. The first three species are known long-distance migrating bats, while the eastern pipistrelle has been described as associated with water.

**Conclusions**
- Floating Laser Wind Sensors are capable of high quality recordings of the wind resource with no operational or statistical significance in recording technology vs. anemometer cups
- This is the first study of Turbulent Kinetic Energy (TKE) offshore by the University of Michigan and Michigan Technological University
- The amount of energy generated depends on the turbine employed, in this case the 2.5 MW turbine generated 7,684 kWh using a 850 kW turbine at 125 meters height
- This is the first offshore study of Birds and Bats by Michigan State University
- This project has created opportunities for public dialogue and community education about offshore wind resource development.

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