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Wind resource development along Minnesota's North Shore of Lake Superior

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ABSTRACT

Wind development is one of the fastest growing sectors in the energy industry today. Under the right conditions it can be a large and sustainable local economic development opportunity. Current wind resource estimates (i.e. MN DOC) for NE Minnesota's Lake Superior Coastal Zone indicate that we have a poor wind resource not suitable for development. However, these wind resource estimates are based primarily on climatological modeling, and are no substitute for site-specific measurements. This project was aimed at achieving three primary objectives: 1. Obtain a minimum of one years worth of quality wind speed data (6/15/2007–6/15/2008) from eight sites (Duluth, Clover Valley, Finland, Lutsen, Grand Marais, Hovland and Grand Portage) along Minnesota's North Shore of Lake Superior; 2. Use this site-specific wind speed data to create a wind resource map for the entire region; 3. Use this wind speed data to conduct community-scale wind development economic feasibility studies. Our results suggest that Minnesota's North Shore of Lake Superior has far higher wind speeds than past estimates indicate, and we have begun working with several communities in this region on the development of their local wind resource.

1. Introduction

Northeastern Minnesota's Lake Superior Coastal Zone is a beautiful (approximately 300 km long and 15 km wide stretch of land along the shoreline of Lake Superior. Current wind resource maps suggest this region of Minnesota has low (9–11 mph {4.3–4.9 m/s}) average annual wind speeds. Coupled with the difficult (topography) and remote terrain, it has long been assumed that economically viable wind resource development is not possible. But each of the author's personal experiences and those of regional wind advocates suggest this region's wind resource may be much better than previously estimated. Therefore, we attempted to better estimate the wind resource along Minnesota's North Shore of Lake Superior with a one-year, multi-site wind monitoring program, and to compare our results with current published estimates. More specifically, we report on three objectives: 1. Estimating the regions wind resource using site-specific monitoring; 2. Extrapolating these estimates to create a regional wind resource map of NE Minnesota's Lake Superior Coastline (from coastline to approximately 15 km inland); and 3. Exploring the economic viability of community scale wind development in this region.

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2. Objective I: wind monitoring

2.1. Methods

2.1.1. Site selection

Our study began with the process of selecting appropriate sites for monitoring the local wind resource. The key criteria dictating site selection included the following: 1. An existing structure that could be climbed and was at least 30 m tall; 2. The presence of prominent peaks; 3. Year round road access to each site; 4. A set of sites that were equally spaced along the Northshore; 5. Ability to obtain permission to have unlimited access to these sites; and finally 6. The presence of good community partners to work with on monitoring logistics and implementation of potential future wind resource development. We were hoping to be able to consistently monitor wind speeds at 30 m to make direct comparisons to earlier modeling results published by the MN Department of Commerce, and to minimize distortions caused by variable surface roughness and elevation at each monitoring site. Prominent peaks were selected to minimize the wind shadowing by nearby peaks, and to obtain what were likely to be the highest wind speeds in the study region, so that our subsequent wind mapping would be extrapolating wind speeds downward rather than upward. We also wanted to obtain direct measurements (not extrapolated) at monitoring sites that likely had potential for future wind development. It is not a perfect methodology for site selection, but it is the best we could do with limited budgets, available monitoring stations and the local interest to actually develop the wind resource at some of our monitoring suites. Fortunately, we were able to meet each these criteria at eight different sites from Duluth to Grand Portage. Fig. 1 illustrates the geographical location of each site. Table 1 lists our monitoring sites, and describes several key characteristics of each.

Table 1
Key characteristics of each monitoring site.

Site	Structure	Elev (ft)	Height (m)	Coordinates
Enger Tower	Tower	1146	32	46.7760, −92.1249
Clover Valley	Fire Tower	1400	36	47.0191, −91.8335
Finland	Fire Tower	1865	40	47.4562, −91.2320
Lutsen	Com Tower	1745	40	47.6643, −90.7069
Grand Marais	Com Tower	1722	34	47.7971, −90.3346
Hovland	Fire Tower	1774	32	47.8760, −89.9691
Grand Portage	Com Tower	1720	30	47.9745, −89.7585
			50	
			80	

2.1.2. Equipment

The wind monitoring component of the project required the following equipment: 1. Anemometers for measuring the wind; 2. Dataloggers for recording the wind speed data; 3. Equipment for mounting the anemometers to the existing towers; 4. Software for downloading the data; and 5. Excel spreadsheets for data analysis and presentation. We chose a durable and inexpensive anemometer made by APRS World LLC. Pictures, calibration information and a detailed technical description of their standard anemometer can be found on their website (www.aprsworld.com). We chose a relatively inexpensive, mid-range Madgetech Pulse 110 data logger, along with necessary cables and data acquisition software. Details for each item can be found on the Madgetech web site (www.madgetech.com). Finally, we used standard one-inch square steel bars along with square and ‘U’ bolts for attaching our anemometers to the existing towers at each site. In addition, some sites required various lengths of one-inch galvanized steel poles.

2.1.3. Installation

Installation began with obtaining permission for access to the towers located on each existing site. Each site was then visited and photographed for use in determining the best method for mounting our anemometers. In order to minimize structural interference on our data collection we attempted to place our anemometers a distance of at least 3 m from the top of the mounting structure, or 4× the width of the mounting structure. We worked with four different types of towers (Enger Tower, Staircase Fire Tower, Communication Tower, and External Ladder Fire Tower). Each tower type required its own particular installation methodology. At Enger Tower we simply bolted a ten-foot galvanized steel pole to the railing at the top of the tower, and mounted our anemometer to the top of the steel pole (Figs. 2 and 3).

Clover Valley and Finland had conventional staircase fire towers. At these sites we bolted two short sections of square steel to the tower windowsills to clear the roof overhang, and extended a ten foot section of square steel from these two supports beyond the roofline. We then attached the anemometer to the top of this extension pole (Figs. 4 and 5).

Lutsen, Grand Marais and Grand Portage had communication towers. At these sites we bolted a 3.2 m section of square steel to the towers, and extended the anemometer 3 m from the towers (Figs. 6 and 7).

Finally, Hovland had a unique external ladder fire tower with a hole in the roofline. At this site we attached a 2.2 cm diameter, 3 m long galvanized steel pole to the floor of the fire tower, and to two window sills using straps. The pole extended beyond the roof-line, and the anemometer was attached to the top of the pole (Fig. 8).

At each site (with the exception of the two stairway fire towers) wire is run down the tower to ground level where it is plugged into the data logger. The data loggers are stored in a safe, dry container. This allows for easy ground access to the data loggers for monthly data collection. In every case we made every attempt to follow the National Renewable Energy Laboratory's (NREL) guidelines for anemometer installation in terms of achieving the appropriate distance from rooflines and communication towers [3].

2.1.4. Data recovery and maintenance

Approximately once every one to two months we visited each site to collect data, and perform any necessary maintenance. The data was collected in two different ways. The first approach consists of preprogramming a data logger in the office (setting the date,

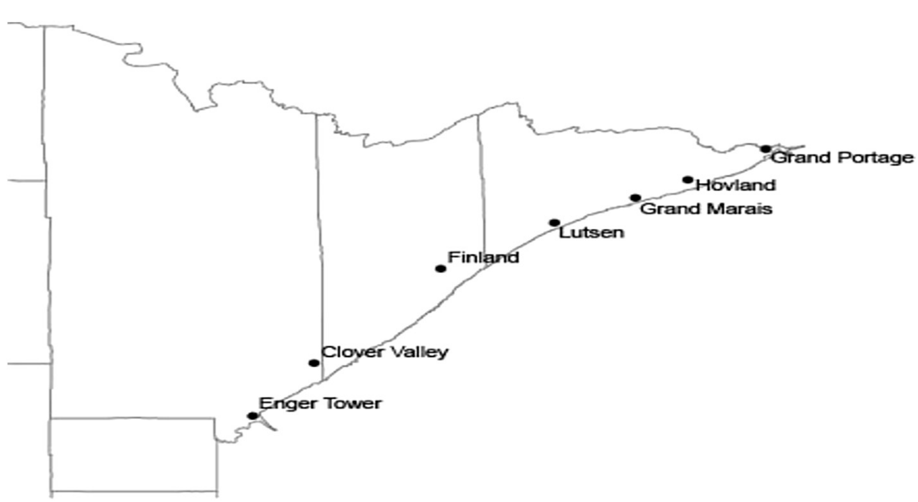

Fig. 1. The geographic location of each monitoring site along NE Minnesota's Lake Superior shoreline.