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Offshore Wind Energy Outreach: Wind Farm Visual Simulation

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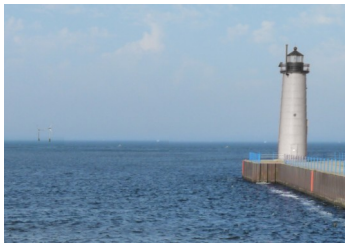

Grand Valley State University and the Great Lakes Commission

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Erik Nordman, Ph.D.

A photo-simulation is the first step in understanding and mitigating the visual impact of wind farms, especially those offshore.

Photo simulation using CanVis

The CanVis software tool, made available by the National Oceanic and Atmospheric Administration, enables planners and scholars to simulate the visual impact of proposed changes to coastal environments. The tool has been used to simulate shoreline changes such as coastal development and sea level rise.

The CanVis tool provides instructions on how to accurately scale simulated objects based on reference objects in a photograph. We followed the same procedure used by the Ohio Department of Natural Resources in simulating the visual impact of a proposed offshore wind project in Lake Erie[1]. We used these methods to simulate the visual impact of a hypothetical, ten turbine, 50 MW offshore wind project in Michigan's Great Lakes waters.

The Image and Reference Object

The CanVis instructions, as well as other sources, state that the perspective of the human eye is best simulated using a camera lens with a 50 mm focal length. We photographed coastal scenes using a digital camera set at a 50 mm focal length.

CanVis requires a reference object to be in the picture. The reference object must be of a known height and distance from the camera. We chose as our reference object one of the many lighthouses along the Michigan coast (the lighthouse's color has been changed to keep the scenario hypothetical). The lighthouse height is 53 feet, and was 597 feet from the camera. We measured the straight-line distance using an aerial photograph in a geographic information system (ArcGIS).

Wind farm scenario

We chose a realistic scenario to simulate based on trends in offshore wind energy development. There is a strong trend toward larger, more powerful wind turbines in the offshore setting. The REpower 5M is one of the largest wind turbines commercially available and is deployed in offshore settings in Europe. We chose this model for our simulation. The Repower 5M is a five-megawatt (5 MW) machine with a hub height of 279-311 feet and a 413 foot rotor diameter. The approximate height of this turbine with the blade in the upright position is 497 feet.

(Continued)

[1] Ohio Dept. of Natural Resources. 2011. Illustrating the aesthetic impacts of offshore wind turbines in Lake Erie. Web site. Available at http://www.csc.noaa.gov/digitalcoast/action/canviserie.html

Offshore Wind Energy Outreach Project

Web site: *www.gvsu.edu/marec/offshore-wind-info-83*

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Source: REpower

A pilot scale project planned in Lake Erie is 20 MW. Given the trend toward larger turbines, we estimated a future pilot scale project to be about 50 MW consisting of ten 5 MW turbines. A wind farm this size could support the needs of 15,00-20,000 homes.

The Michigan Great Lakes Wind (GLOW) Council used a shoreline buffer distance of six miles to define the boundary between "conditional" (< 6 mi.) and "most favorable"(>6 mi.) ratings. We placed our hypothetical wind farm at a distance of 6.2 miles from shore.

Height Calculations and Simulation

The apparent size of a feature in an image is a function of its distance from the camera. We used the known height and distance of a reference lighthouse to estimate the height of a simulated turbine at 6.2 miles The image features were viewed and measured on a computer monitor. The CanVis manual uses the following formula to calculate the height of a simulated feature:

$$I_f = \frac{A_f}{A_r} \times \frac{D_r}{D_f} \times I_r$$

Variable	Definition	Value
A_f	Actual height of simulated feature (turbine)	497' (151 m)
A_r	Actual height of reference feature (lighthouse)	53' (16.15 m)
D_r	Distance from reference feature	597' (182 m)
D_f	Distance from simulated feature	6.2 mi (10,000 m)
I_r	Image height of reference feature	4.3" (0.11 m)
I_f	*Image height of simulated feature*	*0.75" (0.019 m)*
	Turbine / lighthouse height ratio	*4.3/0.75 = 0.17*

Close-up of the simulated turbines

The turbine / lighthouse height ratio applies to the photo-simulation at any size, printed or digital.

Our scenario featured two rows of turbines. Turbines were spaced one half-mile apart within rows and one mile between rows. The same process was used to calculate the size of the turbines in the second row. The turbine colors and brightness were adjusted slightly to mimic atmospheric haze. The horizon has no meaningful effect at this distance.

The photo-simulation was printed on a large banner and also appears below. It is a reasonably accurate approximation of the visual impact of a wind farm sited 6.2 miles offshore.

Offshore wind farm simulation