OFFSHORE WIND FARMS IN THE WESTERN GREAT LAKES: AN INTERDISCIPLINARY ANALYSIS OF THEIR POTENTIAL

by John S. Hingtgen

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at the University of Wisconsin-Madison 2003

ABSTRACT

This thesis is an interdisciplinary study of the potential of offshore wind farms in the western Great Lakes. It includes an opinion survey of representatives of the public, an analysis of potential offshore sites, an estimate of the potential power and energy available, an extensive review of existing European experience, and the discovery of locally relevant information. The opinion survey found that there was a marked preference among respondents in counties bordering the lakes for onshore wind farms over offshore ones. Opposition to offshore projects is stronger along Lake Superior than Lake Michigan. A map analysis identifies several suitable sites along Lake Superior and many sites along Lake Michigan. The potential electric power of wind farms offshore in the study area with constraints applied is estimated to be approximately 9,700 MW. Available information indicates that most environmental impacts would likely be minimal in this area, with the possible exception of perceived view shed impacts.

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I. Conclusions & Discussion

A. Conclusions

An opinion survey of representatives of the public in lakeshore counties showed that there was a strong preference among the 37 respondents for onshore wind farms rather than offshore ones, with 24 respondents (65%) choosing On land and 6 (16%) choosing Offshore; 7 chose Don't know. Wind energy overall was supported, with respondents perceiving that their communities would support more wind farms in their states and near their communities. Opposition became apparent, however, with the possibility of siting farms on land close to shoreline areas.

When respondents were asked about likely community responses to an offshore wind farm placed within sight of various land uses, the only two uses in which the Approve choice was chosen more than the Disapprove choice were industrial and agricultural uses, suggesting that these are the preferred land use types offshore from which to site wind farms.

When asked about siting of energy structures up or down the coast from the shoreline point near their community, respondents were much more likely to accept wind farms than oil or gas drilling platforms. Generator fuel types (including renewable fuel choices) that respondents perceived their communities would favor showed a preference for cleaner fuels.

Respondents had a median time in the community of 25 years, suggesting very good familiarity with their own communities. There was a strong perception among interest groups that their members would favor local ownership and decision making concerning generation plant siting.

Several key questions were chosen to compare opinions about offshore wind near Lake Michigan to opinions near Lake Superior. These were questions 19, 20, 21, 27, and 31, asked of all respondents. The responses from the two lakes were compared using a statistical test for the difference in proportions. Most differences in the proportions marking each answer choice between the two lake subsamples were statistically insignificant. However, five answer proportion differences were significant.

- Regarding the possibility of offshore wind farms anywhere in one of the Great Lakes, the proportion "Very opposed" was greater for Lake Superior than Lake Michigan at alpha=0.10.
- Regarding offshore wind farms in one of the Great Lakes near the respondent's community, the proportion "Very opposed" was greater for Lake Superior at alpha=0.01.

- Also regarding offshore wind energy farms in one of the Great Lakes near the respondent's community, the proportion marking the mid scale (neutral) choice was greater for Lake Michigan than Lake Superior at alpha=0.10.
- Regarding the preference of whether wind farms near the community should be placed on land or offshore, the proportion marking "On land" was greater for Lake Superior at alpha=0.05.
- Also regarding the preference of whether wind farms near the community should be placed on land or offshore, the proportion who marked "Offshore" was greater for Lake Michigan at alpha=0.10.

Initial screening for physically suitable sites for offshore farms was done with recommended criteria of 5 km or greater from the shore and in water depth of 30 m or shallower. A map analysis of potential sites in the study area revealed that there are very few suitable sites along Lake Superior, and each of these has constraints of some type. In contrast, there are many potential sites of considerable size along Lake Michigan, and many of these have no major constraints. Successive screening criteria which were applied included limiting offshore wind farms to those not offshore from concentrations of birds, limiting them to outside of an 8 km buffer distance from parks, and limiting the sites to those likely to have a power capacity of 100 MW or greater.

After applying these three additional screening criteria to potential sites with the right combination of distance from shore and water depth, the power and energy potential within the study area was estimated to be over 9,700 MW and 24 Billion kWh/year. Potential Lake Michigan offshore sites have a much higher power and energy potential than Lake Superior ones do.

Because the statistical tests revealed that there are some geographic differences in perceptions between Lake Michigan and Lake Superior, with Lake Superior respondents more opposed to offshore farms on some test questions than Lake Michigan residents, there is some correspondence between the differences in perceptions and the differences in the wind resource available.

Both offshore and onshore wind farms pose minimal risk to birds. Some evidence suggests that birds would use over-water areas less the farther they are from land. Information available suggests that beyond 1 km offshore, there is little risk that birds will be using the same space as wind farms.

Law and regulations applicable offshore tend to be more concerned with state and federal jurisdictions regarding use of lakebeds and construction in lakes, rather than with local land use restrictions, which are typically applied to onshore projects.

B. Discussion

Offshore wind energy production is a developed means of generating electricity in Europe at present, and the early experimental wind farms have evolved to ones of significant size, with more planned for the future. Several sites have been proposed for development in North America, with at least two in Canada and three in the United States, on both the Pacific and Atlantic coasts and in the eastern Great Lakes.

At any wind farm, public reactions are a crucial factor in permitting and siting. Wind farm developers pursue projects in communities that are more receptive to them. Public opinion would be a key test that projects in the Great Lakes would have to pass.

Responses to the survey questions appeared to be based primarily on the perception that the public would find offshore wind farms easier to see than onshore ones, and that they would find them aesthetically negative. The survey did not suggest to respondents that either of those two perceptions was factual. The fact that only five of the statistical tests resulted in significant differences between the two lakes may be due to having too small of sample sizes to yield more power in the tests.

Several factors are likely to be important in siting future wind farms. The color of turbines and towers should be carefully chosen, as the survey found that colors that blend in are preferred. Yet, international navigation recommendations are for colors that stand out. Ownership is another crucial factor, with co-op ownership preferred by representatives of the public (in contrast to the current trend toward independent power producer ownership). Regarding plant siting, decision making at the local level is also preferred over that of state or higher levels. As the survey indicates, siting wind farms offshore of industrial or agricultural areas is also advisable.

The power estimate developed here for offshore potential is somewhat over half of the onshore power potential of the three states bordering the study area, even though it includes only part of the offshore areas of these states.

A variety of cost values from Europe and the United States, when converted to U.S. dollars and inflated to a recent common year, do confirm that capital costs offshore have been higher. Energy production costs have varied widely, however, and published figures (when converted to recent year values) do not show that offshore energy costs have been higher than onshore energy costs.

Visual impacts from wind farms can be less offshore, depending upon distance from the coast. However, this depends upon weather offshore, as well as how well onshore wind farms can be visually screened by landscapes.

C. Suggestions for future research

Future investigations of appropriate offshore siting should concentrate on Lake Michigan areas, both for the above considerations, as well as to take advantage of the greater electricity demand centers along Lake Michigan. They should focus on areas that are offshore of agricultural or industrial areas as sites most likely to receive positive public reaction to siting proposals. They should also attempt to survey the public with more extensive information provided about the comparative impacts and advantages of different energy sources. Determining reliable estimates for the cost of adapting to ice loading on foundations would be useful. Updating and expanding the information on bird concentration sites along the lakeshores would be valuable. Also useful would be basic research on how wind farm construction and operation sounds would be perceived by fish.