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Offshore Wind Energy: Public Perspectives and Policy Considerations

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Offshore Wind Energy

PUBLIC PERSPECTIVES AND POLICY CONSIDERATIONS

WEST MICHIGAN WIND ASSESSMENT ISSUE BRIEF #3

The West Michigan Wind Assessment is a Michigan Sea Grant-funded project analyzing the benefits and challenges of utility-scale wind energy development in coastal west Michigan. More information about the project is available at http://www.gvsu.edu/wind.

- *There are two types of wind energy facilities: onshore and offshore. This brief is about offshore wind development.*

Wind energy can be harnessed to produce electricity through two different types of facilities: onshore and offshore developments. Onshore wind projects typically include a group of wind turbines constructed on land – in coastal, forested or agricultural areas with strong winds. Very similar wind turbines can also be constructed offshore in lakes or the ocean. Currently, most offshore wind turbines are mounted on cement foundations or driven into the sea floor in areas where water depths do not exceed 100 feet (Figure 1).

While there are currently no offshore wind farms located in North America, that may soon change. Offshore projects have been proposed for locations along North America's Eastern Seaboard and in the American and Canadian waters of the Great Lakes. North American residents, including Michiganders, have many questions regarding offshore wind energy. **This report examines social issues related to offshore wind, including public acceptance, visibility, noise and tourism. The final section reviews wind policy and regulatory issues in Michigan.**

This brief summarizes peer-reviewed journal articles and technical reports about offshore wind developments. Future issue briefs will examine environmental, economic and technological issues.

Weighing the Options

- *Currently, there are no offshore wind farms in North America, but several have been proposed for the Great Lakes.*

Locating turbines offshore rather than on land offers several important benefits, as well as some significant drawbacks. A recent planning document of the U.S. Offshore Wind Collaborative stated that America's offshore wind resource is vast and plentiful [1]. Winds tend to blow harder and more consistently offshore than over land, which could produce a steadier supply of electricity. The sporadic nature of onshore wind energy production creates some challenges for our current electrical grid system. In addition, offshore turbines could be established close to cities along the Atlantic and Great Lakes coasts, reducing power transmission issues. Offshore turbines can be larger and rotate faster than land-based models, in part because turbine noise is much less likely to disturb

Figure 1. Wind turbines at the Horns Rev wind farm, Denmark (photo: DONG Energy).

people. The technology needed for offshore wind facilities has been well tested and could produce energy more efficiently than onshore wind farms. However, permitting and construction of offshore wind projects is challenging.

Some advantages of offshore wind:

- *More consistent wind*
- *Proximity to large cities and energy centers*
- *Larger and faster turbines*
- *Located where noise is less likely to disturb people*

The most substantial hurdles for potential offshore wind farms are construction costs and public acceptance. Offshore wind turbines require elaborate foundations and transmission infrastructures, which can appreciably increase the development and maintenance costs as compared to onshore installations. Public perceptions and acceptance have generally been mixed. Opposition to offshore wind energy development is complex and concerns range from economic and aesthetic impacts to preservationist approaches that advocate keeping the Great Lakes free of any development.

Offshore wind energy development in Lake Michigan is a particularly sensitive issue. A survey by the Joyce Foundation found that Michigan residents – more so than residents of other Great Lakes states – agree that "each of us has a personal responsibility to protect the Great Lakes." Michigan residents are also more likely to see the Great Lakes as "vast, beautiful, vulnerable, relaxing places for recreation" [2].

Some drawbacks to offshore wind:

- *Construction costs*
- *Public acceptance*
- *Could negatively affect people's connection to a landscape*

Michigan's current energy portfolio has considerable negative – though mostly invisible – impacts on the health of the Great Lakes. Michigan generates nearly 60 percent of its electricity from coal-fired power plants, and approximately 25 percent from nuclear power. Electricity production is one of the major sources of pollution in the Great Lakes. Mercury deposition from coal burning power plants contributes to fish consumption advisories and other health impairments [3]. The intake of water for cooling of both coal and nuclear facilities entraps large numbers of fish. The discharge of warm water from these same plants has negative consequences for lake ecosystems [4]. Fossil fuel-based electricity generation contributes to climate change, which threatens the health of the Great Lakes region**. Considering the impacts of current energy generation raises the question: Could carefully sited offshore wind energy projects improve the quality of the Great Lakes through reduced emissions from other electricity sources?**

- *Michigan generates nearly 60% of its electricity from coal-fired power plants, which negatively impact fish, wildlife and human health.*

Locating Offshore Wind Projects

To better understand Michigan's offshore wind energy options, this brief draws upon studies of offshore wind projects in Europe, a thorough assessment of a proposed project in Massachusetts (Cape Wind) and several reports prepared for Michigan. The first large offshore wind farm was built in 2002 at Horns Rev, Denmark (Figure 1). In 2009, 1.2 percent of all wind energy production globally was generated by offshore wind installations [5]. Twelve nations, including 10 countries in Europe, currently have offshore wind farms. The United Kingdom and Denmark – the two largest producers – account for more than half of the world's offshore capacity. China increased its offshore capacity in 2009 with a 21 megawatt (MW)[1] wind farm near Shanghai, and Japan has a single offshore turbine.

Although there are no offshore wind farms in the Western Hemisphere, many places including Michigan have strong offshore wind resources. Briefings prepared for the Michigan Renewable Energy Program and the Michigan Great Lakes Wind Council are

[1] A megawatt (MW) is a measure of electrical generating capacity. A 2 MW wind turbine can power about 600 Michigan homes. The West Michigan Wind Assessment website has a glossary of wind energy terms at http://www.gvsu.edu/wind/project-documents-3.htm.

good sources of information about potential offshore wind energy development in Michigan [6,7]. The 29-member Council was formed in 2009 by executive order of the governor and recently produced a comprehensive report (See: http://www.michiganglowcouncil.org/index.html).

The Michigan Great Lakes Wind Council developed a set of criteria to identify areas of Michigan's Great Lakes that are "most" and "least" favorable for offshore wind energy development. The Council tried to avoid underwater archeological sites, sensitive habitats and military operation areas. They looked for areas with at least 20 square miles of contiguous bottomland and water depths of 45 meters or less. The Council found that Michigan waters have 475 square miles of bottomland that are "most favorable," and they identified five wind resource areas that are most appropriate for offshore wind energy leasing: southern Lake Michigan, northern Lake Michigan, central Lake Superior, central Lake Huron and southern Lake Huron (Figure 2). The west Michigan coastal region within this project's focus area was not named as one of these most favorable areas. The water depth increases quickly with distance from shore along the west Michigan coast which contributed to its less favorable status [7].

- *The Michigan Wind Council identified five areas that are most appropriate for offshore wind development.*

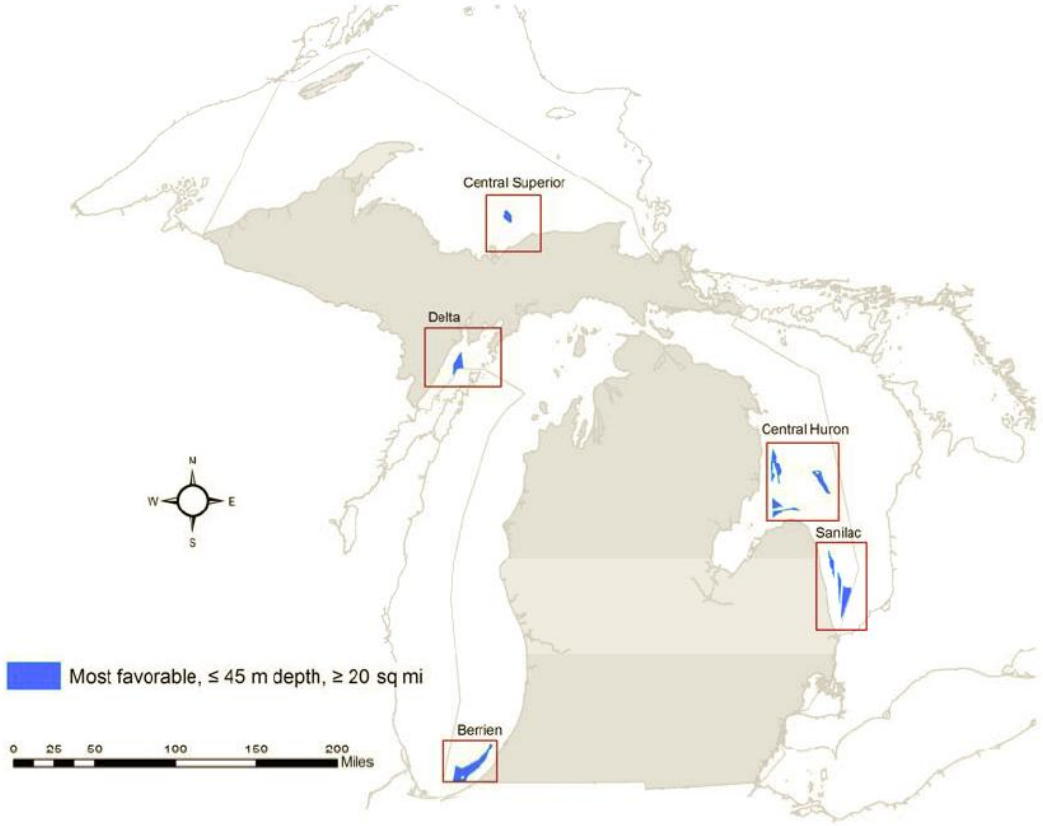

Figure 2: Wind resource areas recommended by the Michigan Wind Council in June 2010 [7].

- *Water depths in Lake Michigan increase rapidly with distance from shore. This means that offshore wind turbines are likely to be located within view of the shore.*

Public Acceptance of Offshore Wind

The aesthetics of offshore wind is a common cause for concern. The costs of current offshore wind technology limit the placement of wind turbines to waters less than 100 feet in depth, which is often within view from the shore. Since Lake Michigan water depths increase rapidly with distance from shore, using existing technology would mean offshore wind farms would likely be located in areas visible from shore.

Public attitude toward offshore wind is apt to vary from place to place, depending on the culture, economy, coastal development and recreational uses of the coast. This section explores the public attitude toward, and the acceptance of, offshore wind farms, using available research papers and technical reports, many from other countries. Two example cases show some similarities to west Michigan.

Example Case 1: Wind Farms in Denmark

- *In Denmark, the public is very accepting of their large offshore wind farms.*

Two of the first large offshore wind farms were constructed off the coast of Denmark in 2002 and 2003, providing a chance to evaluate environmental and social impacts over time. A variety of studies have looked at public attitudes before, during and after their construction by reviewing media coverage, surveying the public and conducting interviews with outspoken community members. (Three reports were part of the Danish monitoring program and were not peer-reviewed [8,9,10]. However, some of these results were later published in scientific journals [11,12,13]). People in two coastal areas of Denmark reacted differently.

- The Nysted wind farm was built six miles offshore from the quiet, scenic coastal area of Lolland, Denmark. Interviews showed that people who opposed the development were worried that the 72 turbines would spoil their unique, natural scenery, and their concerns remained unchanged after construction [8]. A survey conducted one year after construction indicated that 26 percent of area residents felt the turbines had negatively impacted the view. However in the same survey, 86 percent of respondents were supportive of new offshore wind farms in Denmark [9]. A new turbine manufacturing plant brought jobs to the area, which has relatively high unemployment.

- *Opposition based on aesthetics persisted after construction while economic concerns dissipated.*

- The Horns Rev wind farm was built eight miles offshore from an area with a bustling tourism industry, popular beaches and many summer homes (Figures 1 and 3). People who opposed the wind development were concerned about the impacts on business and property values. Before construction, there was a more vocal opposition group in this area than in Lolland, but interviews revealed that many of the opponents modified their views after construction [10]. The interviewer summarized people's views: "Tourists still pay visits to the area, and the fear of a decrease in the summer house prices has, thus far, proven to be groundless; as the prices here have increased concurrently with the equivalent prices applying to the other places in the country" [10, p. 10]. Two years after construction, 12 percent of residents felt the wind turbines negatively impacted the view and 89 percent supported new offshore developments in Denmark [9].

In these two coastal areas of Denmark, surveys indicate that people are more supportive of additional wind development offshore than onshore [9]. People across Denmark felt similarly – 25 percent of respondents opposed new onshore developments and only 5 percent opposed new offshore wind farms [11]. However, people who use Denmark's beaches frequently and who live near Nysted, the closer of the two wind farms, were more likely to oppose offshore wind [12,13].

Figure 3. The view of Horns Rev wind farm from the nearest shoreline, 8 miles away.

Example Case 2: Cape Wind

- *The Cape Wind project is the first offshore wind farm approved in North America. It is used as a case study throughout this brief.*

Cape Wind is the first offshore wind farm proposed in the U.S. and its detailed environmental impact assessment provides a good U.S. case study [14]. Cape Wind was proposed in 2001 and construction is expected to begin in late 2011 in Nantucket Sound between Cape Cod and Nantucket Island, Massachusetts (Figure 4). The developer plans to build 130 turbines with blade tips reaching 440 feet above sea surface (Figure 4). Researchers from the University of Delaware led by Dr. Jeremy Firestone have been studying public acceptance of offshore projects, including Cape Wind. In a 2005 survey conducted by these researchers, a majority (55%) of Cape Cod residents were opposed to the proposed Cape Wind offshore wind farm. Cape residents expected more negative outcomes from the proposed project than positive outcomes. Researchers found the following patterns:

- Residents expected negative impacts on aesthetics, community harmony, fishing, boating, property values and tourism;
- Residents expected positive impacts on job creation, electricity rates and air quality;
- Many respondents would increase their support if Cape Cod received the electricity, if electricity rates decreased, if local fishing was helped and if air quality improved;
- Supporters tended to be younger, were more likely to be homeowners and had higher educational attainment;
- Opponents were more likely to earn more than $200,000 per year and were more likely to see the proposed project site during their daily routine [15].
- More recent opinion polls show that the Cape Wind project has been gaining support among residents [16].

- *In 2005, 55% of the residents opposed the Cape Wind project.*

Figure 4: Simulated view of the proposed Cape Wind project, from 6.5 miles away (Photo credit: Cape Wind).

- *People may support offshore wind in general, but oppose a specific project.*

What Influences Attitudes?

A number of researchers have tried to explain the public's perception of offshore wind. Danish scholar Dr. Jacob Ladenberg reviewed studies from Chile, Sweden and Australia and found that if given a choice between siting a wind farm in a generic onshore or offshore location, people preferred the offshore location. In contrast, when asked about specific, familiar locations, people would chose to locate a wind farm onshore [17]. What determines people's opinion of a specific project?

- *In one major study, aesthetics was the most common reason for opposition, while energy was the primary reason for supporting offshore wind development.*

The location of turbines and their visibility from shore is clearly an important factor. In a coastal region of Germany, where 54 percent of coastal residents disagree with a planned offshore project, aesthetics was cited as the most common reason for opposition, while energy was the primary reason for support [18]. Ladenberg and others have found that people consistently prefer wind farm locations further from shore. However, the benefit that people perceived from moving a hypothetical wind farm an additional mile offshore diminishes with distance. That is, people are more sensitive to the differences between a wind farm at six versus seven miles from shore, than when comparing a wind farm at 12 versus 13 miles from shore [17].

The existing coastal landscape also influences people's attitudes toward a proposed offshore project. In a survey of environmental advocates in Europe, almost all respondents supported offshore wind development in more industrialized or military landscapes, but nearly all would oppose projects in natural areas or sensitive coastal landscapes [19]. In Delaware, residents expressed less support for an offshore project in Delaware Bay, as opposed to the ocean when surveyed. Semi-enclosed water bodies like Delaware Bay and Nantucket Sound (the location of Cape Wind) seem to be less accepted by the public than sites in the open ocean [16].

Differences in a coastal region's economy, culture and recreation are likely to be important as well. In Denmark, studies show that residents appreciate their country's prominent position in the wind industry and the jobs this brings [10]. In the U.S., Firestone's research group compared surveys of residents in Cape Cod and Delaware. Delaware residents were much more in favor of offshore wind energy development. More than 75 percent of the residents, including 65 percent of coastal residents, supported offshore development and only 4 percent of respondents were opposed [16]. The broad support in Delaware may be due to a recent electricity rate increase and the fact that the question, at the time of the survey, was hypothetical.

- *People seem to be less accepting of wind developments in bays than the open ocean.*

The studies reviewed above, while not exhaustive, suggest that people are generally split when asked whether they support or oppose hypothetical wind farms. Although attitudes vary regionally, most people prefer that the offshore wind farms be located farther from shore. Residents are generally supportive of the few existing offshore wind farms in countries like Denmark.

Conversations about Offshore Wind

- *People tend to be more accepting of offshore turbines that would be placed in a more industrialized coastal landscape.*

Some researchers have taken a more qualitative approach to studying attitudes toward wind energy development, especially offshore wind. Geraint Ellis and his colleagues at Queen's University in Belfast, Northern Ireland, used such a descriptive approach. Rather than looking for percentages of support or opposition, they sought to characterize the points of view held by supporters and opponents of a planned offshore wind project in Northern Ireland. Ellis and his colleagues found that the respondents fell into one of eight categories, called discourses: four that describe opponents, and four that describe supporters (Table 1)[20]. This type of work can help public officials better understand and communicate with different people when considering offshore development in their communities.

The descriptive approach also uncovered some areas of consensus among respondents. Both objectors and supporters of the planned offshore wind energy project recognized that climate change is an important challenge that needs urgent attention. All respondents also agreed that the seascape of Northern Ireland is a valuable aesthetic asset. Both supporters and opponents have complex views that are not neatly captured in simple opinion polls [20].

Opponents	Supporters
Anti-Wind Power – Local Resister Skeptical of wind power in general, suspicious of developers; a vigorous, active opponent.	*Rationalizing Globally – Sacrificing Locally* Views local aesthetic and other impacts as necessary to achieve broader goals of sustainability.
Wind Power Supporter – Siting Sheriff Generally supports wind but has site-specific concerns.	*Local Pastoralist – Developer Skeptic* Reluctantly supports the project, putting sustainability goals ahead of developer suspicion.
Anti-Developer – Pragmatic Localist Concerns about developers' motives override strategic issues of climate change and energy security.	*Embrace Wind* Enthusiastically and uncritically supports wind power.
Economic Skeptic – Siting Compromiser Stresses local, short-term negative impacts of offshore wind project; emphasizes economic rationale for decision-making.	*Energy Pragmatist* Energy concerns are a priority; supports wind as a pragmatic, but not the only, solution for energy and climate challenges.

Table 1: Offshore wind opponent and supporter discourses (from Ellis and colleagues [20]).

Dr. Robert Thompson of the University of Rhode Island says the shore is a place of complex ecological and social conditions where a disproportionate number of property conflicts arise [21]. He describes a number of viewpoints, or cultural models, Americans hold about the shore, often simultaneously (Table 2). Conflict can arise when groups of people with varying cultural models and expectations about appropriate uses of coastal resources come into contact.

Thompson invokes these models to explain conflicting expectations regarding the proposed Cape Wind offshore wind project in Nantucket Sound. For example, Thompson describes one resident using a landscape model when the resident states: "The sense of the infinite horizon will be lost." Some coastal property owners ascribe a traditional private property approach to the Cape Wind project, in that the wind turbines are impinging on a view they have paid for. Other people invoke a moral sentiment in their feelings toward the shore – nature as a temple not to be desecrated. According to Thompson, there is no correct model or viewpoint. All of these are legitimate and the multiplicity of models helps resource managers and citizens alike understand their own perspectives and those of others [21]. This cultural model approach sheds more light on the complexity of wind farm acceptance than a typical NIMBY (Not In My Backyard) characterization.

Cultural Model	Description
Sovereignty	Traditional private property, based on boundaries and control
Community	A sense of place based in social interaction emphasizing proper behavior
Landscape	Visual amenity
Ecology	Ecosystem functions and the services they provide
Moral order	Nature as a temple; a sense of wonder
Commodity	For sale to the highest bidder
Productivity	Using resources to enhance human well-being

Table 2: Cultural models of property (from Thompson [21]).

- *An offshore wind farm could threaten people's emotional connection to a familiar landscape.*

Other researchers have also moved beyond NIMBY in describing public acceptance of wind farms. Dr. Patrick Devine-Wright advocates that "so-called NIMBY responses should be re-conceived as place-protective actions, which are founded upon the processes of place attachment and place identity" [22, p. 432]. Michigan's official nickname is the "Great Lakes State" with shores on four of the five Great Lakes, so it seems likely that many residents have a strong attachment to the Lakes. Some residents could understandably see an offshore wind farm as a threat to their emotional connection with a familiar location.

Public Attitudes in West Michigan

In west Michigan, two groups organized around a proposed offshore wind farm in Lake Michigan, outside of Muskegon and Ottawa counties; one group is in support of the project and one is in opposition to it. The language of the groups – particularly that of the opposition group – reflects the nuances described above. The Lake Michigan POWER Coalition describes its position as opposing "any industrial offshore wind power plant proposals that could negatively impact Lake Michigan's waters, regional economy, shoreline ecosystem, and quality of life…" [23]. Using Thompson's cultural model approach (Table 2), the coalition could be described as having community and landscape viewpoints. The group argues that the proposed offshore project may negatively affect the quality of life for shoreline communities. In other words, from their perspective it may not be a good neighbor.

- *A group that opposes wind development on Lake Michigan emphasizes preserving the coastal landscape and quality of life.*

The recent "No Mistake in the Lake" billboard campaign features an image of an uncluttered, seemingly infinite horizon on Lake Michigan (Figure 5). This suggests that the visual amenity of an undisrupted horizon is important to the coalition, consistent with the landscape cultural model. The group members have an attachment to the shoreline and derive some of their identity from being part of lakeshore communities. This kind of place attachment and place identity is consistent with Devine-Wright's concepts. Both the cultural models and the place attachment ideas give a much richer picture of offshore wind acceptance than a simplistic NIMBY description. It is also true that wind farm supporters have an attachment to the shoreline, but they emphasize different values and uses.

Figure 5: The Lake Michigan POWER Coalition opposes offshore wind energy development in areas of West Michigan (Photo credit: J. VanderMolen).

Visibility on the Lake

The visibility of offshore projects impacts aesthetics and influences public acceptance. Depending on its distance from shore and weather conditions, a potential wind farm on Lake Michigan would not always be visible from land. Haze, clouds and fog, for example, limit visibility on the lake. The Michigan Wind Council assumed wind farms would be located beyond a six-mile buffer from shore in its final report [24]. **How often would turbines be visible from shore?**

- *A wind farm located six miles offshore in Lake Michigan would be visible about 64% of the time, based on average weather conditions.*

The National Oceanic and Atmospheric Administration's (NOAA) Great Lakes Environmental Research Laboratory maintains a database of ship weather logs, including observations made from the S. S. Badger ferry each time it crosses Lake Michigan between Ludington, Michigan and Manitowoc, Wisconsin [25]. This information was used to estimate the percentage of days in which visibility exceeded two distances: six miles and 13 miles in the summer of 2010. For all times of the day, visibility exceeded six miles 64 percent of the time and exceeded 13 miles 18 percent of the time (Figure 6). This suggest that a wind farm six miles from shore would have been visible about two-thirds of the time during the summer of 2010. A wind farm 13 miles from shore would have been visible less than one-third of the days during the summer.

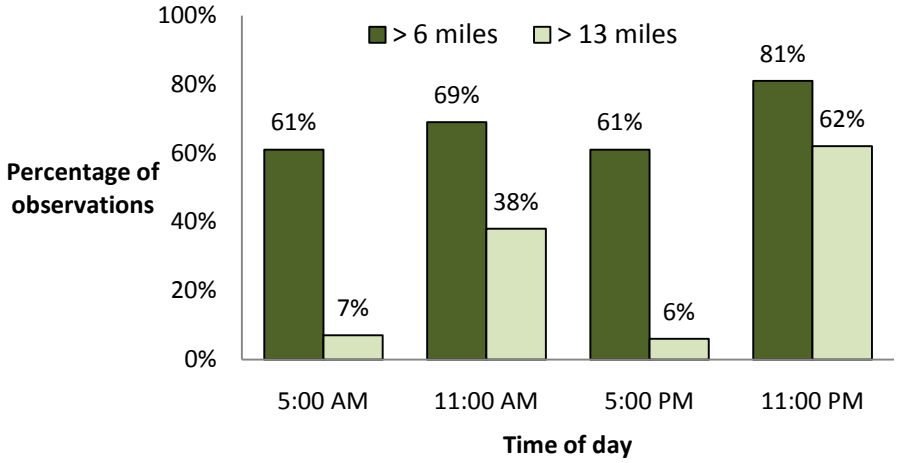

Figure 6: Percentage of observations where visibility on Lake Michigan exceeded 6 miles and 13 miles. Observations were made from the S.S. Badger ferry, June 3 to September 6, 2010.

Offshore Wind Turbine Noise

- *Wind turbines installed offshore can be larger than land-based models, but they produce similar levels of noise.*

Wind turbine noise in onshore settings is generally well understood, although the issue of low-frequency sounds and infrasound is subject to continued investigations. More detailed information about wind turbine noise can be found in *Wind Power and Human Health: Flicker, Sound, and Air Quality*, an issue brief from the west Michigan Wind Assessment (See: www.gvsu.edu/wind)[26].

Wind turbines installed offshore typically have longer blades that can rotate at faster speeds; however, the sound level produced is only somewhat higher than turbine models used onshore. The proposed offshore project near Cape Cod would be located five miles from shore and use 3.6 MW turbines that generate slightly more sound at the source than a typical, large onshore turbine [14]. In contrast, current onshore developments in Michigan's Thumb have installed turbines with a 2.5 MW capacity, with a minimum set back of 1,000 feet from residences. Because offshore wind farms are located much further from people, sounds from normal turbine operation would not normally be audible on land; however noise during construction may impact boaters.

Less information is available about how turbine sounds travel away from an offshore turbine than from a land-based turbine. Karl Bolin and his Swedish colleagues were among the first to evaluate the propagation of wind turbine sounds over a sea surface [27]. Sounds can reflect off of the water and propagate farther than similar sounds on land. The propagation of these sounds is dependent on the sound's frequency and

- *Sound from an offshore wind turbine can reflect off the water and travel farther than similar sounds on land, although very little sound would reach the shore six miles away.*

atmospheric conditions. Bolin and his colleagues evaluated the propagation of a low-frequency test sound (80 hertz (Hz)[2], 113 dB[3]) across a variety of atmospheric conditions. When the wind blew more strongly at the surface than at higher elevations, the test sound became trapped near the surface and lost about 60 to 70 dB of its original strength over six miles. Under more typical, turbulent atmospheric conditions, the test sound decayed more rapidly (greater attenuation), losing 100 dB at six miles. In both situations, the sound would be inaudible above background noise at a distance of six miles (K. Bolin, personal communication, 16 November 2010).

The most recent and relevant information comes from the Cape Wind project's *Final Environmental Impact Statement* [14]. The proposed Cape Wind project is located about five miles offshore in Nantucket Sound. A team of environmental analysts measured background noise levels onshore in quiet rural areas after the end of the tourist season. Average background sound levels ranged from 35 dB(A) to 73 dB(A), with the lowest measurement at 27 dB(A). In general, higher wind speeds generate more background noise. During peak operation times, sounds from Cape Wind would range from 12 to 26 dB(A) at onshore locations, well below background noise levels. The authors of the Cape Wind impact statement concluded that the development is "anticipated to be inaudible at shoreline locations" [14, p. 5-15]. In addition, their calculations demonstrated that non-motorized sailboats between 0.3 and 1 mile away from the proposed wind farm would not experience any additional noise (14, p 5-14]. The background noise of wind, waves and boats would mask the sounds of normal turbine operation.

The Cape Wind Environmental Impact Statement also considers low-frequency sounds, which are generally defined as frequencies from 1-100 Hz [28]. The human ear is much less sensitive to low frequency sound and, for most people, a noise at 16 Hz must be at 92 dB to be detectable. However, low frequency sound can travel further than mid-range sounds and this has been a source of some concern around onshore wind farms. Low frequency sounds generated by Cape Wind would decay to approximately 50 dB at onshore locations, which is undetectable by most people [29].

- *Construction of turbines will generate noise that boaters in vicinity will hear. Rarely will these sounds be audible on land.*

Pile-driving activity during the construction phase of offshore wind farm development can be noisy. Analysts predict a noise level from pile-driving to range from about 46 to 51 dB(A) within 0.3 to 1 miles from the activity. This noise may impact boaters present in the vicinity of the construction work [21]. Pile driving noise at the turbine site closest to an onshore location (up to 40 dB(A) at five miles) could be audible to people on shore if winds are blowing onshore and background noise is very low [14, Appendix 5-11 A]. Noise related to a single turbine construction is temporary, but it could take from one to two years to build all the turbines and lay the necessary cables for a utility-scale wind development.

Comparing wind turbine sounds to more familiar sounds can help clarify unfamiliar sound measurements. For example, Michigan boating laws require that a "vessel's muffler or exhaust system must prevent noise in excess of 90 dB at idle from three feet away and 75 dB when measured from the shore" [30]. Based on the Cape Wind models, the expected loudness of an offshore wind turbine and the pile-driving activity would be much lower than the legal limit for motorboats and personal watercraft operating

[2] Hz: A **hertz (Hz)** is a measure of frequency, or the number of times something occurs in a second. In terms of sound, 1 Hz (Hertz) = 1 cycle of the sound waveform per second.

[3] dB: A **decibel** (**dB**) is a measurement of sound intensity. It is not an absolute measure, but measures differing levels relative to each other. A commonly used measure is the A-weighted dB scale, abbreviated dB(A).

on Lake Michigan waters relative to an onshore observer. The timing, duration, and qualities of boat and wind turbine sounds differ, but the comparison to boating allows communities to imagine and evaluate how wind turbines noise might affect their coastal areas.

- *Studies in Cape Cod indicate that about 4% of tourists would visit less often if turbines were built offshore; 1% would visit more often.*

Tourism

Tourism-dependent coastal communities in west Michigan are keenly interested in the potential effects of offshore wind farms. The lack of established offshore projects in North America allows only for anecdotal and hypothetical conclusions regarding the impact of offshore farms on tourism.

The Beacon Hill Institute at Suffolk University in Massachusetts surveyed Cape Cod tourists and residents in 2003 about the Cape Wind proposal. The majority of respondents (94%) said they would not change the frequency of visits to Cape Cod if the wind farm were to be constructed. About one percent would visit more often, three percent would visit less often and two percent would not visit Cape Cod at all. The Beacon Hill Institute scholars estimated that the net effect of these tourist decisions would be a reduction of local economic output of $94-$203 million annually [31].[4] Economic issues related to offshore wind will be discussed further in an upcoming issue brief.

- *Surveys of beachgoers in Delaware indicate that some would avoid a beach with an offshore wind farm.*

An extensive literature search revealed no studies that measured the impact of constructed offshore wind farms on the number of visitors, tourism business or summer home property values. However, a number of researchers have polled residents and tourists about their attitudes toward potential offshore wind energy development. Researchers at the University of Delaware asked out-of-state beachgoers a series of questions on offshore wind development. Eighty-five percent (85%) of the respondents had positive attitudes toward wind power and supported their offshore placement. When shown a series of images of wind projects at one mile, six miles, and 13 miles from shore, a majority of respondents said they would still visit the same beach if the wind turbines were constructed at any of those identified distances [32]. In addition, the following results were also noted:

- *A coal or gas power plant six miles from the beach would impact visitation more than an offshore wind farm.*

- A higher percentage of beachgoers would continue visiting if the turbines were further offshore: about 55 percent for one mile offshore; about 75 percent for six miles offshore; more than 90 percent at 13 miles; and 99 percent if the turbines were out of sight.
- Most of those respondents choosing a different beach under these scenarios would choose a different beach in the same state (Delaware).
- A coal or natural gas power plant six miles from the beach would reduce estimated beach visitation by 12.5 percent more than a wind farm six miles offshore.
- About 65 percent of respondents would visit a new or different beach at least once to see an offshore wind farm. Nearly half of those surveyed would pay to take a boat tour of an offshore wind farm [32].

[4] While this paper was not published in a peer-reviewed journal, the Beacon Hill Institute is known to be a credible, though not necessarily non-partisan, source of information. The Beacon Institute describes itself as being "grounded in the principles of limited government, fiscal responsibility, and free markets." (See: http://www.beacon hill.org/mission.html)

- *Understanding actual tourist behavior in response to offshore wind energy development is still an open area of research.*

Impacts for West Michigan

No formal survey regarding an offshore wind farm's effect on tourism in Michigan has been completed yet. The Michigan Wind Council has sponsored several informational meetings around the state, including meetings in Muskegon and Grand Rapids. The events have been well attended. Informal polls of meeting attendees indicated a range of views on offshore wind in the Great Lakes, including questions about tourism. A majority (53%) of attendees voiced support for a hypothetical offshore wind farm six miles from the coast (Table 3). The attendees were not a random sample of the population, so the results cannot be extrapolated to the rest of the state [7].

	Benefit	No effect	Harm	Unsure
Tourism	29%	31%	37%	3%
Michigan job creation	74%	16%	7%	2%
Aesthetics	16%	28%	54%	2%
Property values	14%	40%	40%	5%
Recreational boating	17%	42%	38%	3%

Table 3: Responses of Michigan Wind Council workshop attendees to the question: How would an offshore wind farm six miles from the coast affect the region? [7].

The limited body of published information indicates that some tourists would avoid a beach with an offshore wind farm, particularly if it were relatively close to shore. However, coal or natural gas power plants could have a similar or greater impact on potential visitors. A wind farm could also create new business opportunities, such as chartered boat tours. The presence of a visitor information center can draw tourists to a specific viewing location. However, no studies have tried to measure changes in tourist behavior in response to a constructed offshore wind energy development.

- *Permitting an offshore wind farm is complex – it took Cape Wind nine years to secure a permit.*

Policies and Regulation

Many groups in west Michigan are interested in how potential offshore projects will be reviewed, permitted, taxed and regulated. Offshore projects would be located on lake bottomlands, which are owned and managed by the state. How will towns near a proposed project be involved in decision-making and revenue sharing?

- *The bottomlands of Michigan's Great Lakes are owned and leased by the state.*

Permitting an offshore wind farm is more complex than permitting onshore facilities. As the first proposed offshore wind development in the U.S., it took nine years for the Cape Wind project to receive a permit. This section focuses on the permitting process for the offshore development of wind energy in Michigan's Great Lakes. The section synthesizes the findings of the Michigan Great Lakes Wind Council (also known as the GLOW Council), particularly the *Michigan Great Lakes Offshore Wind Permitting Dry Run* and the Council's final report. These and other useful documents are available on the Michigan Wind Council website: www.michiganglowcouncil.org. Most of this information applies statewide and not exclusively to the west Michigan region.

Current Policies and Regulations

In 2008 various Michigan agencies met to evaluate the state's readiness to authorize an offshore wind farm in the Great Lakes. The group created a fictitious company that proposed two hypothetical wind farms – one for a nearshore location in Lake Huron and the other in a deepwater location in Lake Michigan. The group proceeded through a "dry run" for issuing a permit for these two hypothetical projects. Each agency analyzed the processes it would use to fulfill the permit requirements. At least eight

state and federal agencies were identified as having a role in the permitting process [33].

- *Permitting of offshore projects in Michigan would involve at least five federal agencies and three state agencies.*

Since the bottomlands of Michigan's Great Lakes are owned by the state, any offshore project would likely require a bottomland lease to drive a monopile into the lake bottom, to set a gravity foundation on the bottom, or to tether a floating system. The *Michigan Natural Resources and Environmental Protection Act,* Great Lakes Submerged Lands section, states that a permit is required for the placement of a permanent structure in the Great Lakes. The Michigan Department of Environmental Quality collaborates with the United States Army Corps of Engineers (USACE) on a joint permit process for bottomland leases. The state-federal joint permit and the state bottomland lease are separate but parallel processes. The U.S. Environmental Protection Agency would be involved under the requirements of the *National Environmental Protection Act*, in coordination with the USACE. The U.S. Fish and Wildlife Service (USFWS) would assist in evaluating impacts on fish and wildlife and is required to review the joint permit. The USFWS authority comes from a number of federal statutes, including the *Endangered Species Act*, the *Migratory Bird Treaty Act*, and the *Bald and Golden Eagle Protection Act* [33].

- *Local governments have some authority to regulate the land-based side of an offshore project – the substations and transmission lines.*

Utility-scale wind turbines are tall structures that could potentially interfere with aviation and the radar systems of the Department of Defense and the Department of Homeland Security. The Federal Aviation Administration (FAA) and the Michigan Department of Transportation collaborate on regulating structures more than 200 feet tall, including the requirements for safety lighting. Although the FAA has the authority to regulate activities that could interfere with radar systems, radar issues were not discussed during the dry run. The U.S. Coast Guard requires a permit to operate a private aid-to-navigation system on a fixed structure, such as a navigation buoy or light that protects an offshore wind development [33].

State and federal agencies also regulate the electrical transmission system for a wind power project. The Federal Energy Regulatory Commission authorizes wholesale electricity generators to sell power at market-based rates. The Michigan Public Service Commission regulates electricity transmission, including the construction of new major transmission lines. Local units of government, acting through their zoning ordinances, have some authority to regulate onshore transmission facilities, such as a substation on land that connects an offshore wind project to the electrical grid system [33]. Local units of government do not have jurisdiction over state-owned bottomlands.

- *There are presently no clear guidelines for offshore wind development leases.*

While the joint permitting process itself appeared adequate in the dry run, the specifics of bottomland leases are not suited for offshore wind farms. According to the dry run final report, there are presently no clear guidelines for offshore wind development leases to aid decision-makers. Revising the bottomland lease details could be accomplished by either administrative rulemaking or legislative action. Key areas in need of clarification include establishing a fair value for bottomland leases for offshore wind projects and mechanisms for distributing the benefits of the offshore lease to the whole state [33].

Policy Recommendations

The Michigan Wind Council was also charged with providing input on legislation and rulemaking regarding offshore wind development in the Michigan's Great Lakes. The Council proposed a leasing and permitting process for offshore wind energy development that includes site nomination, a public auction, initial site assessment, and lease and permit for construction and operation. Public engagement would occur at

several points and include public notices, comment periods and public meetings. The permitting of an offshore project would trigger a *National Environmental Policy Act* assessment, which requires substantial public input. Details for the scope of the proposed public engagement process can be found in the Wind Council's final report.

The bottomlands of Michigan's Great Lakes are held in trust by the government for the benefit and use of the citizens of Michigan. The public, therefore, is entitled to compensation for the use of Great Lakes bottomlands for offshore wind energy development. The Council recommended two methods for public compensation: rent and royalties, the standard compensation methods for oil and gas leasing on public lands [7].

- *The Council recommends that the state collect rent and royalties from wind projects, similar to oil and gas leasing on public lands.*

The Council recommended that the state collect rent from bottomland lessees at $3 per acre, per year [7]. The $3 per acre rate was considered very carefully by the Council. The rental rate is based in part on the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement's rates for leases on the marine coasts (M. Klepinger, Staff Director, Great Lakes Wind Council, personal communication 21 December 2010). The recommended lease rate is within the range of rates for oil and gas leases on public property, which vary from $2.00 to $5.00 per acre, per year based on the length of the lease [34].

The Michigan Wind Council also recommended that the Michigan Public Service Commission (MPSC) collect royalties from offshore wind projects based on revenues. The suggested royalty rate was at least three percent of projected gross revenues, but they encouraged the MPSC to be flexible in setting the royalty rates [7]. For comparison, royalties for oil and gas leases on state lands are one-sixth (16.7%) of the gross revenues generated by extracting oil and gas. [34]. Finally, the Council recommended that the state establish a Great Lakes Wind Energy Trust Fund. The royalty payments from offshore wind leases would contribute to the trust fund. The trust fund monies would be used for research, monitoring and mitigation of impacts from offshore wind development, promotion of energy efficiency, and administration of offshore wind energy regulations [7].

- *Royalties could support research, monitoring and mitigation through a trust fund.*

In late 2010 Michigan Representative Dan Scripps introduced House Bill 6564 to the House Committee on Energy and Technology. This bill included many of the Wind Council's recommendations for leasing bottomlands and permitting offshore wind energy development. However, the legislative session ended without the bill making it out of committee. A new governor and legislature took office January 2011, and it is unclear how they will use the Council's recommendations.

Conclusions

Offshore wind energy development is technically feasible and the engineering continues to improve. Offshore regions have tremendous wind resources, but are more costly to access.

The public attitudes toward offshore wind development are mixed here in Michigan and elsewhere. Studies indicate that acceptance tends to increase as distance from shore increases and with repeated exposure to the wind farm. The public also finds the context of offshore development important – more developed seascapes are generally more acceptable locations than wild areas. Social scientists have found that concepts like cultural models and place attachment better describe the complexity of public acceptance, as opposed to simple NIMBY attitudes.

Coastal residents are concerned about the visibility and noise of a potential wind project. Projects located further than six miles from shore will only be visible when days are clear, roughly two-thirds of the time or less. Research from the proposed Cape Wind offshore project indicates that the noise generated by wind turbines five miles offshore would not be audible on land.

Tourism is a crucial part of many coastal economies, but there is no evidence that existing offshore wind farms in Europe support or hinder tourism. Surveys show some tourists may avoid beaches with a view of an offshore wind farm, while other tourists might seek them out. Boat tours may provide another line of business for charter captains.

Offshore wind in the Great Lakes would occur on lands owned and managed by the state and a range of federal agencies would be involved in permitting. The permitting process is slow, but there are a number of opportunities for public involvement. Guidelines for approving a project and sharing revenue still need to be established.

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