

Offshore Wind Energy in Michigan

Economic costs and benefits

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Credit: Corbis Images

Offshore Wind Energy Outreach Project

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

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Introduction

Offshore wind farms generate low-pollution electricity in many northern European countries, China, and Japan, but there are no offshore wind projects in the U.S. or Canada. This fact sheet explores the economic dimensions of offshore wind, including the costs, the effects for electricity users, and the conditions that enhance its economic viability. The fact sheet also describes the potential economic benefits of offshore wind energy. Finally, the lessons are applied to Michigan's Great Lakes.

Comparing Energy Production Costs

Estimating the cost of new electricity generation is complicated and involves many assumptions. No organization has a clear view of the future, but cost estimates can be useful planning tools. One common way of comparing different types of power generation is to calculate the "levelized cost of energy" for existing or planned power plants. These cost estimates take into account construction and operating expenses, energy production capacity and the expected life span of a facility, but do not consider policy incentives, financing options or potential impacts to the environment or public health.

The U.S. Energy Information Administration (EIA) and Google's clean energy initiative have estimated the levelized cost for carbon-free electricity in the U.S. from various sources (Figure 1). The EIA estimates that the cost of electricity from a new offshore wind farm would average \$243/MWh [1], while Google uses more optimistic pricing assumptions and estimates the levelized cost to be \$196/MWh [2]. For comparison, the Michigan Public Service Commission estimated the levelized cost of *onshore* wind at \$102/MWh and a new coal plant in Michigan, including the cost of emissions compliance at \$133/MWh [3].

These estimates indicate that the levelized costs associated with offshore wind are comparable to those for solar photovoltaic panels (PV), but about double the costs for onshore wind, nuclear, conventional coal and coal with carbon capture and storage.

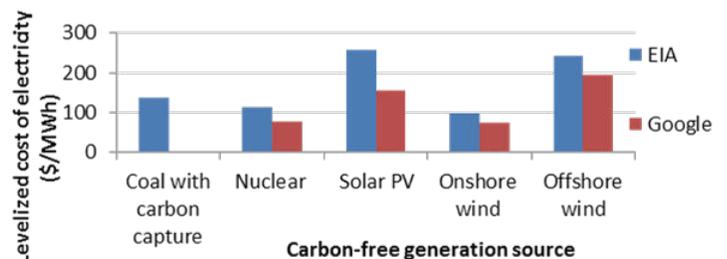


Figure 1: Levelized cost of different types of power generation. Note: Google does not expect carbon capture to be available in the short term, so no price is recorded. Source: EIA 2010 [1] and Google 2011 [2]

Variable Market Prices of Offshore Wind Power

The first few offshore projects in the U.S. are likely to be expensive, but costs should decline as the industry gains experience.

No offshore wind projects have been built in North America, and therefore, the first few projects are likely to be relatively expensive. Andrew Levitt and colleagues at the University of Delaware estimated the electricity price required for offshore wind farms to break-even and attract investment under different market and policy conditions in the U.S.[4]. Using detailed cost and revenue information from existing and planned wind farms around the globe, they found that the expected break-even prices could be lowered through policies like investment tax credits or government ownership business models, factors that are not included in the previous section's levelized costs. Levitt's group found that prices were most influenced by the maturity of the wind industry in a particular region. As an example, Figure 2 illustrates the estimated break-even electricity price for hypothetical offshore wind farms in the U.S. using expense information from three different types of projects: a new project in a region without any offshore wind development ("first of a kind"), the average, existing offshore wind farm ("global average"), and a recently constructed offshore project in a mature market such as northern Europe under the best conditions ("best recent value")[4]. Prices decline substantially as the firms involved, from construction to finance, gain experience developing offshore wind energy.

Several offshore wind projects have been proposed along the U.S. East Coast, but none have broken ground yet. Three projects have developed agreements with utility companies that will buy and distribute electricity generated from the planned offshore wind farms (Figure 2). The demonstration project near Block Island in Rhode Island agreed to sell its electricity at \$237/MWh. The Cape Wind project off the coast of Cape Cod, Massachusetts has a contract price of \$186/MWh. Utilities in Delaware agreed to purchase electricity from the NRG Bluewater wind project for \$99/MWh [4]. These power purchase agreements span the full range of break-even price estimates from Levitt and colleagues. The range of prices reflects a wide variety of local conditions, including state electricity markets and policies, undersea environments, and grid infrastructure.

Studies indicate that costs associated with the first few offshore projects in the U.S. could be three times more expensive than the most recently constructed offshore developments elsewhere, but costs should decline over time [4]. In regions like northern Europe, the organizations involved in financing, constructing, maintaining and regulating wind farms have gained experience and have built the supply chains and infrastructure needed to efficiently harness offshore wind resources [4].

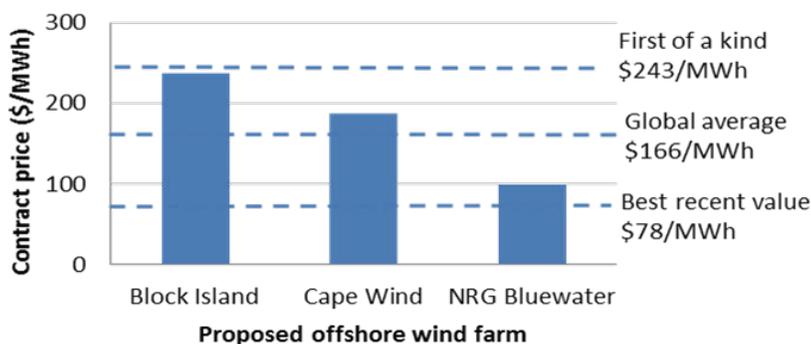


Figure 2. The electricity contract prices for proposed offshore wind farms in the U.S. Dotted lines indicate the estimated break-even electricity price of a corporate financed project with accelerated depreciation and a production tax credit. Source: Leavitt et al. 2011 [4]

No offshore wind proposal in the Great Lakes region (U.S. and Canada) has progressed to the point of having a power purchase agreement with a utility. It is unclear what the levelized cost or market price of electricity might be for a project in Michigan's Great Lakes. Given the lack of specialized vessels and challenging conditions, such as ice cover, the first projects in the Great Lakes region could have costs in the range of Levitt's estimates for first of a kind projects.

Impacts on Electricity Prices for Consumers

Proposed offshore wind projects along the East Coast are likely to raise monthly electricity bills by \$1.35 to \$6.50.

Offshore wind energy projects have higher levelized costs than some other renewable energy sources. Individually, however, each offshore wind energy project adds a modest amount of electricity to the grid, and the higher price of offshore wind energy is diluted by the rest of the energy portfolio. For example, the Cape Wind offshore project is expected to increase the average residential electricity bill by \$1.59 per month [5]. The NRG Bluewater wind project in Delaware is expected to increase the average utility bill by \$6.50 per month [6]. Block Island, off the coast of Rhode Island, currently generates electricity by means of diesel generators. The pilot-scale Block Island Wind Farm would produce electricity for the island and is expected to *lower* residents' electricity bills. Other Rhode Island residents will see an increase of \$1.35 to \$3.00 per month [7]. The likely electricity rate impact of an offshore wind energy project in Michigan's Great Lakes is unknown at this time.

Advantages of Offshore Wind

The economic viability of offshore wind depends on the location of a project, the existing energy market and policy incentives. Although the power produced by the three proposed offshore wind farms in the U.S. will be expensive, the Public Service Commissions of Delaware and Massachusetts have approved the power purchase agreements because the projects could help meet the state's renewable energy goals and provide a stable source of clean energy over the long-run [4]. In urban, densely populated states along the East Coast, a congested electricity grid, lack of suitable land for onshore wind, and high electricity prices make offshore wind relatively more attractive.

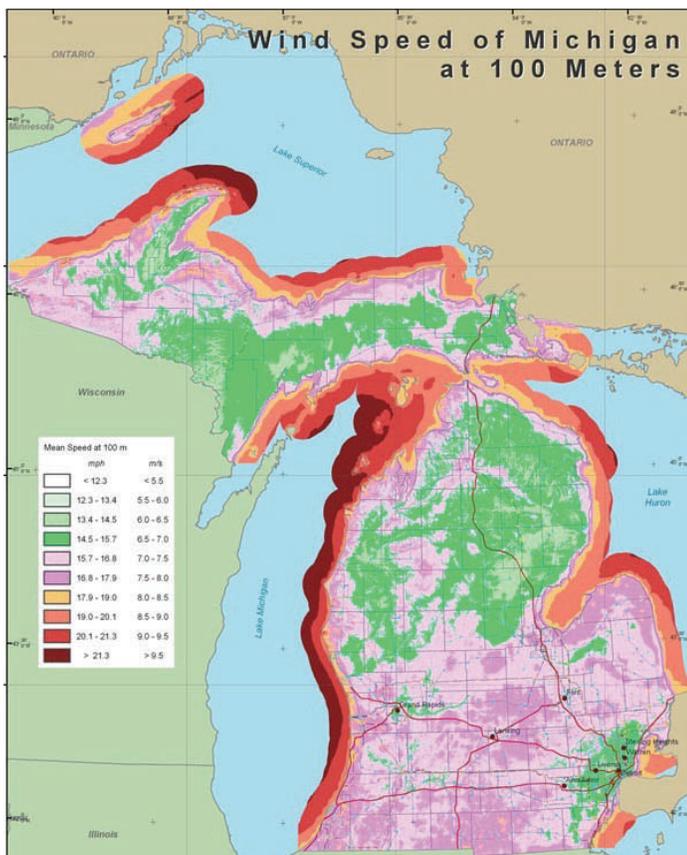


Figure 3: The darker red indicates stronger winds.

Source: Mich. Dept. Energy Labor and Economic Growth

An offshore location means that electricity can be generated and delivered to urban demand centers by traveling as few as 6 to 10 miles. This could avoid building additional above-ground, long-distance transmission lines to support other types of land-based electrical generation.

Offshore winds blow faster, more consistently and with less turbulence than onshore winds and can generate electricity more efficiently. In Michigan, the fastest wind speeds occur off Michigan's west coast where winds can average more than 20 miles per hour (Figure 3) [8]. Cost-effective offshore wind development would require access to high-voltage transmission lines near the shore, whether near coastal cities or existing energy infrastructure.

Spillover Effects

Offshore wind energy has both positive and negative effects that are not reflected in the market price of electricity. These effects, called spillover effects or externalities, include the potential impacts on views, recreation activities, water use and air pollution. Economists have tried to quantify these complex effects.



Figure 4: Turbines that are close to shore can have a visual impact.

Source: GE Energy

Estimating the Aesthetic Costs

Aesthetic impacts from offshore energy are a concern (Figure 4). A study conducted by Grand Valley State University concluded that the visibility of an offshore wind farm was a key concern among the participants from the West Michigan region [9]. The Michigan Great Lakes Wind Council (GLOW Council) had similar findings [10]. Several studies have estimated the dollar value of the aesthetic impact of offshore wind developments.

Research has shown that, all things being equal, people prefer offshore wind farms to be located farther from shore. There are no offshore wind farms in North America, so it is not possible to directly observe people’s reactions to offshore wind farms, such as changes in beach visits or property values. In such cases, economists use surveys and ask questions about hypothetical scenarios to understand preferences and how much people would pay to avoid or make specific changes in their environment.

In a survey from Delaware, participants answered questions about whether they would accept a higher renewable energy fee in their utility bill in exchange for siting the hypothetical wind farm farther from shore. In this experiment, the hypothetical wind farm consisted of 500 turbines (440 feet tall) for a total wind farm capacity of 450 MW located 0.9, 3.6, 6.0 or 9.0 miles from shore [11]. People’s responses depended on the distance between the shore and the turbines, the age and education level of a respondent, and the location of their home relative to the coast. Surveys in Delaware indicate that the perceived cost of offshore turbines 6 miles ranged from about \$35/year for residents of ocean-side communities to \$0.78/year for inland residents. The estimated aggregate impact for all Delaware residents (317,000 homes) of the hypothetical offshore wind farm are presented in Table 1. The aesthetic costs associated with a wind farm 1 mile from shore is about nine times greater than for a wind farm 9 miles from shore [11].

This study indicates that the visual impacts of a wind farm could be minimized dramatically by moving turbines out to 6 miles; however, the aesthetic impact of turbines at 6 and 9 miles is relatively similar.

The Delaware study did not consider the impacts on non-residents and tourists, which could be significant. While Delaware has some notable differences from Michigan — including the saltwater setting — the results do provide a starting place for discussion and additional research. A formal, state-wide survey of Michigan residents would help clarify their attitudes toward the visual impact of offshore wind farms in Michigan’s Great Lakes.

Distance from shore	0.9 miles	3.6 miles	6.0 miles	9.0 miles
Total aesthetic cost of offshore turbines for Delaware residents	\$7.6 million/year	\$4.2 million/year	\$1.1 million/year	\$0.87 million/year

Table 1: The estimated value of the visual impact of a hypothetical 500-turbine offshore wind farm in Delaware at various distance from shore. Source: Krueger 2011 [11].

Benefits of Reducing Pollution

Developing wind energy facilities could reduce our dependence on polluting fuels such as coal over the long run, which could have important benefits for public health and the environment (Figure 5). Nordman and colleagues reviewed 13 scientific studies on the pollution-reduction potential of wind energy, all of which concluded that integrating wind energy into the electric grid can reduce emissions of air pollutants such as carbon dioxide (CO₂), sulfur dioxide (SO₂) and, in most cases, nitrogen oxides (NO_x) [12].

A 450 MW offshore wind farm could reduce pollution from other electricity sources, generating health and environmental benefits that range from \$1.1 million to \$29.5 million per year.

Estimating the dollar value of cleaner air, healthier children and a more stable environment seems impossible, but many economists have tried. The U.S. Department of the Interior gathered a number of published cost estimates for how pollution from different energy sources (coal, natural gas, nuclear and hydroelectric) damages human health, the aquatic environment, society and climate. Using these studies they estimated the economic value of avoided pollution from a hypothetical offshore wind farm in the Mid-Atlantic region of the U.S. If the electricity from one 360 MW offshore wind farm replaced other fuels proportionally to their current electricity production levels, the benefits from avoided pollution could range from \$0.9 million to \$13.5 million per year. The benefits would be even greater if wind power replaced exclusively coal-fired power plants, which results in more pollution than, for example, natural gas [13].



Figure 5: The primary benefit of wind energy is that it could displace more polluting fuels, such as the BC Cobb coal-fired power plant in Muskegon, Mich.

Applying the same methodology and using Michigan’s electricity generating mix [14], we estimated that a 450 MW offshore wind farm (as used in the Delaware analysis above) could provide benefits ranging from \$1.1 million to \$19.4 million per year by reducing pollution. If a new wind farm replaced only coal-fired plants, then the benefits range from \$1.6 million to \$29.5 million per year (Table 2). The estimated benefits for avoiding pollution are ballpark figures and should not be taken as definitive.

	Wind replaces existing energy proportionately	Wind replaces only coal- fired plants
Low estimate	\$1.1 million/year	\$1.6 million/year
High estimate	\$19.4 million/year	\$29.5 million/year

Table 2. Estimated air pollution avoidance benefits of a 450 MW offshore wind farm in Michigan’s Great Lakes.

Weighing the Costs and Benefits

Some people may be interested in comparing the costs and benefits of offshore wind development in the Great Lakes. Based on the estimates presented in this fact sheet, the benefits of reducing pollution are greater than the cost of the visual impact for a hypothetical 450 MW wind farm located 6 miles offshore. However, this comparison does not take into account other potential costs and benefits, many of which are hard to measure and predict, such as the psychological effects of a changed landscape, or potential impacts on property values, tourism, jobs and future electricity prices.



Figure 7: The NoordzeeWind Information Centre in Egmond aan Zee, Netherlands, draws visits from tourists and residents.
Credit: Noordzee-Wind

More than 80% of Delaware residents would visit a new or different beach just to see an offshore wind farm.

In addition, the costs of an offshore wind farm are most likely to affect people very close to the development, while the benefits will be distributed across a broader region. Thus an individual's personal calculation of perceived costs and benefits will vary across Michigan.

Property Values and Tourism

Property value reductions are a concern for many, but to date none of the published, peer-reviewed scholarly articles on the topic have shown a consistent property value effect from constructed wind farms, onshore or offshore [15].

There is evidence that, in some locations, offshore wind farms may not substantially affect tourism. A survey of Delaware residents found that 89 percent of respondents would continue to visit the same beach if an offshore wind farm were constructed 6 miles from shore. About 84 percent would visit a new or different beach just to see an offshore wind farm [16]. These are expressed intentions, not actual behaviors, but it suggests that wind energy development far from the coast could be compatible with tourism.

The Egmond aan Zee Offshore Wind Farm in the Netherlands is located 6-11 miles offshore from the beach town of Egmond aan Zee (Figure 6). The wind farm operators have conducted public opinion surveys of residents, businesses and tourists. Of tourists who had seen the offshore wind farm in person, 5 percent found the view very disruptive, 17 percent found it a little disruptive, and 79 percent did not find the view disruptive at all [17]. This study was not peer reviewed, but it is one of the few studies that documents the opinions of tourists viewing operating offshore wind farms. The community hosts the Noordzee Wind Information Centre which provides information about the wind farm to tourists and residents alike (Figure 7).



Figure 6: The sun sets behind the Egmond aan Zee offshore wind farm in the Netherlands.
Credit: Noordzee Wind.

The potential tourism impact of offshore wind energy in Michigan's Great Lakes is unclear and additional place-specific research is needed.

Potential for Economic Development

A large construction project such as an offshore wind farm will employ people in the manufacturing of components, assembly, construction and installation (Figure 8). The Cape Wind project's environmental impact statement states that the 420 MW project Massachusetts would employ 391 full-time workers over a 27-month construction period. Secondary employment effects, such as restaurant workers catering to construction crews, could range from 588 to 1,772 jobs. About 50 workers would be employed in the operation and maintenance of the finished offshore wind farm and another 104 workers would be supported indirectly [18].

The project will pay the Town of Yarmouth, Massachusetts \$350,000 per year for the onshore portion of the electrical interconnection line [18]. Like most other economic development analyses, these employment numbers do not consider the effects of jobs that could be lost in other sectors.

A similarly sized offshore wind project in Michigan's Great Lakes could have an impact close to that projected for Cape Wind. However, additional Michigan-focused research is necessary to estimate the costs, benefits and economic development potential for offshore wind energy in Michigan. For example, the potential to build wind turbine parts in Michigan will determine how much wind farm construction benefits employment within the state. Many wind turbine parts are already being manufactured in Michigan, such as the turbine blades made by Holland-based Energetx. The National Renewable Energy Laboratory is developing an offshore wind energy module for its Jobs and Economic Development Impact tool, but the tool is not yet available. Such a tool would enable Michigan communities to explore, in more detail, the economic development impact of offshore wind projects.

Conclusions

The levelized cost to produce electricity through offshore wind facilities is currently higher than most other sources of low-pollution electricity and is about double that for land-based wind energy. However, the levelized cost does not include social or environmental costs and benefits. Researchers in Delaware estimated an offshore wind farm's visual impact cost to residents at \$1.1 million per year for a project located 6 miles from shore. Delaware's conditions are different from Michigan's, so it is unclear precisely how Michigan residents might react to an offshore wind farm.

We estimated the external benefits of replacing more polluting generation sources at between \$1.1 million and \$29.5 million per year. This estimate is a ballpark figure and is not definitive. The results of the visual impact and pollution-reduction studies suggest that the main external cost (visual impact) is equal to or less than the main external benefit (pollution avoidance).

Other potential non-market costs and benefits include tourism and recreation. The qualitative evidence for these is mixed: people might avoid or actively seek out tourism and recreation opportunities near offshore wind farms. Estimates from the Cape Wind project suggest that a large offshore wind farm could employ nearly 400 people during the construction phase and 50 for wind farm operations.

Offshore wind energy is a new technology not just for Michigan, but for all of North America. It offers low-pollution electricity, but could transform the shoreline in host communities. The current price of electricity from offshore wind is likely higher than what the Michigan market would bear, but it could be economically viable if the costs come down. With this fact sheet, and its companion environmental impact fact sheet, we hope to inform the discussion of offshore wind energy in Michigan.



Figure 8: Constructing an offshore wind farm could employ nearly 400 workers.

Credit: Noordzee Wind

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Please visit our project web site for more information about the benefits and challenges of offshore wind energy in Michigan's Great Lakes. Web site: www.gvsu.edu/marec/offshore-wind-info-83

Additional information about offshore and land-based wind energy is available through the West Michigan Wind Assessment project web site: www.gvsu.edu/wind.

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