

Wind Farms and Navigation

POTENTIAL IMPACTS FOR RADAR, AIR TRAFFIC AND MARINE NAVIGATION

WEST MICHIGAN WIND ASSESSMENT ISSUE BRIEF #9

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The West Michigan Wind Assessment is a Michigan Sea Grant-funded project analyzing the benefits and challenges of developing utility-scale wind energy in coastal West Michigan. More information about the project, including a wind energy glossary can be found at the website, www.gvsu.edu/wind.

Wind turbines and their associated navigational features, such as warning lights, may disrupt radar systems, cause visual impacts, and affect recreational boating and other activities.

Introduction

Navigation is defined as the process of monitoring and controlling a craft, such as an airplane, car or boat, from one place to another [1]. Early navigators relied on celestial bodies such as the sun, moon, planets and stars to guide them to their destinations. Today, pilots and mariners are aided by state-of-the-art navigational systems, such as radar, that quickly identify incoming crafts, weather and other potential obstacles. Additionally safety lights placed on tall obstacles, such as radio towers and wind turbines¹ are often the first and last warnings available to pilots and sailors about potential hazards to navigation.

This issue brief examines the navigational challenges associated with wind turbines and the options for mitigating these effects. This summary includes the disruption that wind turbines may have on radar systems, the visual impacts of warning lights, and the effects on recreational boating and other water-related activities.

Case Study: Cape Wind

This issue brief discusses navigation issues related to both onshore and offshore wind projects. Although there are no constructed offshore wind farms in the U.S., the Cape Wind project has been approved for construction in Nantucket Sound, off the coast of Massachusetts. This planned project will be referenced throughout this brief to illustrate key concepts. The Cape Wind project will consist of 130 turbines within a 24-square-mile area, with each turbine about 0.4 to 0.6 miles apart. The turbine blades will have a rotor diameter of 341 feet and will be mounted on a 246 foot tower, which means the tip of the blades will reach 417 feet above the sea [2]. The configuration of wind turbines was chosen to be technically efficient and economically viable, while also allowing for the continuation of existing water activities such as fishing, boating, sailing, etc. [2].

¹A **wind turbine** is a machine that captures the force of the wind. This and other wind energy related definitions can be found using the WMWA's Glossary at www.gvsu.edu/wind. Other terms not defined in the glossary will be defined in this paper as footnotes.

Wind Turbines and Radar Systems

Radar (Figure 1) is a technology that many people use or experience daily without even knowing it. For example, imagine going to the airport to pick up a relative. Before leaving, you watch the weather report on TV to see if there is precipitation in the forecast that may delay the flight. On the way to the airport you pass a police officer watching for speeding motorists. Once at the terminal you look at the flight status monitor that indicates when your relative's flight is expected to arrive.

All of these situations used radar. Research has shown that wind farms can interfere with radar systems; however, with the proper technology in place, this effect can be minimized.

Concerns that utility-scale wind farms will disrupt radar have delayed the construction of new wind facilities.



Figure 1: FAA's ARSR radar system (Photo: J. VanderMolen).

Radar is an acronym for Radio Detection and Ranging. A radar dish or antenna sends out pulses of radio waves, which bounce off any object in their path and return to the antenna. A radar system detects the size and location of different features in its line of sight (e.g., clouds, planes) by measuring the strength of radio waves that are reflected by these features [3].

The motion of a spinning wind turbine blade can intercept a radar signal and cause "clutter."

Radar is used every day by the National Oceanic and Atmospheric Administration (NOAA), the National Weather Service (NWS), the Federal Aviation Administration (FAA), the United States Department of Defense, the Department of Homeland Security, and many other federal and private organizations to track everything from weather patterns to airplanes to threats to national security. Concerns that utility-scale wind farms will disrupt radar have delayed the construction of new wind facilities.

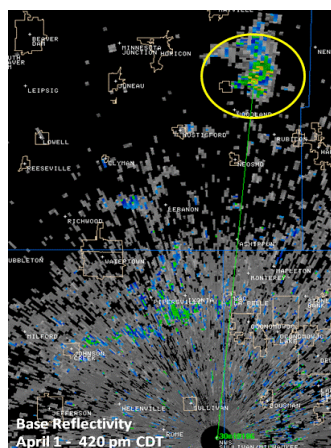


Figure 2: Wind turbine cluttering (yellow circle) of a NOAA-NWS radar in Wisconsin (Photo: NOAA-NWS Milwaukee).

Wind turbine clutter can cause certain features, such as weather patterns or aircraft, to be temporarily lost or shadowed by the wind farm's radar signature.

The Michigan WERZ Board identified coastal Allegan County as a high potential for wind energy, with Muskegan, Oceana, and Ottawa counties as alternatives, but the potential impact on radar systems was not considered.

The motion of a spinning wind turbine blade can intercept a radar signal and cause “clutter.” The blades of a turbine typically have tip speeds that are six to seven times greater than the wind speed [6]. The radar system interprets the motion of the blades as a moving target of significant size (Figure 2) [7]. Wind turbine clutter can cause certain features, such as weather patterns or aircraft, to be temporarily lost or shadowed by the wind farm’s radar signature² [3; 4]. Several factors influence how much wind farms impact a radar system, including:

- The distance between the radar system and the wind farm [5].
- The height, size and number of turbines that make up a wind farm [8].
- The age of the current radar system [6].

Due to concerns about radar interference with aircraft navigation, federal regulations require the FAA to be notified prior to the construction of all objects taller than 200 feet. The FAA then conducts an aeronautical study to determine whether the proposed structure would present a hazard to air navigation [9]. Because of this policy, the FAA has issued a number of “Notices of Presumed Hazard” for many wind farm projects. The Dept. of Homeland Security has also issued a temporary policy contesting the location of wind farms within their radar systems’ sight lines.

Wind and Radar in West Michigan

In 2009 the Michigan Wind Energy Resource Zone (WERZ) Board identified the western portion of Allegan County as one of four regions in the state of Michigan with a high potential for generating wind energy. This assessment was based on the amount and type of land available and the wind conditions in a region. Coastal areas of Muskegon, Oceana and Ottawa counties were also recognized as an alternative region for wind energy development using the same criteria [10].

The effect that the wind turbines may have on nearby radar systems and the restrictions set forth by the FAA and the Dept. of Homeland Security were not considered by the WERZ Board when choosing these locations. Figure 3 identifies the areas in West Michigan where construction of wind turbines may impact Department of Defense long-range radar. Wind farms could be built within a radar impact zone, but steps may need to be taken to lessen the potential effects on radar. The appropriate federal agencies have the power to approve or block wind energy development.

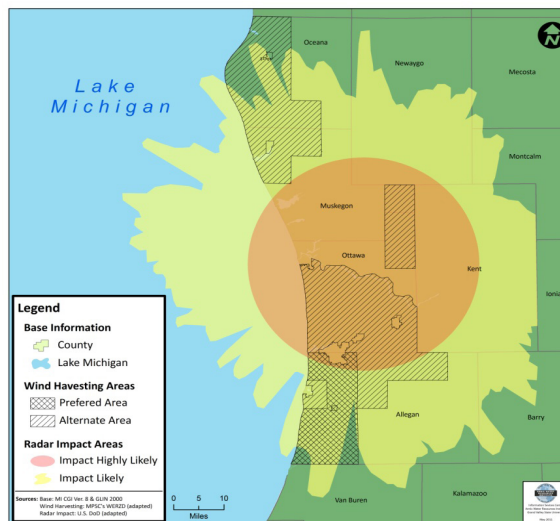


Figure 3: Areas in West Michigan where wind turbines could disrupt long-range radar.

²A radar signature, also known as a radar cross section (RCS), is a measure of how detectable an object is with radar.

Results from the regulating agencies like the FAA, NOAA and the DHS do not mean that a wind farm cannot be placed in an impact area, but that developers must mitigate potential radar impacts.

Material engineers have developed turbine blades built with radio wave absorbing material to reduce a wind turbine's radar signature and signal clutter.

The U.S. Department of Defense preliminary screening tool suggests that the only areas in the region that may not interfere with their radar system are located in northern Oceana County, south-central Allegan County, and the extreme southwest part of Allegan County. The impact areas extend offshore, particularly in Muskegon and Ottawa counties.

The preliminary results displayed in Figure 3 do not replace the processes and procedures that would have to be followed with the U.S. DOD, the FAA and other regulating agencies. Furthermore, these results do not automatically mean that a wind farm cannot be placed in an impact area. For example, the proposed Cape Wind project off the shores of Massachusetts will be located in an “impact likely” area and a similar project, the Forward Wind Energy Center in Wisconsin is located in an “impact highly likely” area³.

For a wind farm to be successful, developers must team with regulating organizations like the FAA, NOAA and the Dept. of Homeland Security (DHS) to mitigate the challenges of possible radar interference. These issues can be addressed in two ways: 1) adjusting to wind turbine structure and location; and 2) modifying radar systems.

Adjustments to Wind Farm Location and Structures

The radar impact screening tool created by the Dept. of Defense, allows communities and wind developers to screen sites for possible impacts early in the development process. Developers can then choose more suitable sites that do not interfere with radar operations. Presently, projects moving forward in an impact area will likely be contested by federal agencies. The U.S. DOD and the DHS issued a joint interim policy in 2006 stating that, “the DOD/DHS Long Range Radar Joint Program Office Interim Policy is to contest any establishment of windmill farms within radar line of site of the National Air Defense and Homeland Security Radars. This is to remain in effect until the completion of the study and publishing of the Congressional Report” [11].

Regulating agencies in the United States could build upon the current policies in place in European countries such as the United Kingdom, Germany, Netherlands, Austria and Norway. Most of these countries have policies that require developers of wind farms to get special permission for their projects. All of these countries have established “protection zones” ranging from 6 to 58 miles (5 – 50 nautical miles) around military radar systems [7].

Material engineers have developed turbine blades that can reduce a wind turbine's radar signature. Usually turbine blades are hollow and constructed with glass-reinforced plastics that are highly reflective to radar waves [12]. Engineers are now installing a material on the outside (or inside) of a blade that absorbs the radio waves of the radar. This would then shift the structure's Doppler signature to outside of the frequency range read by the radar system, thus reducing the signal clutter associated with the turbines [6].

The new blade technology is being tested at the Hare Hill wind farm in the United Kingdom. The results of this test show that blades treated with radar absorbing materials were less detectable by the radar systems of nearby airports. This treatment increased the cost of the blades by about 10 percent [12]. Applying

³Coordinates used for Cape Wind analysis were: 41° 32' 31" N by 70° 19' 16" W. Coordinates used for the Forward Wind Energy Center analysis were: 43° 37' 1" N by 88° 29' 28" W.

materials that absorb radar waves will never completely eliminate a wind farm's radar interference. However, combining this technology with upgrades in the radar system's hardware and software can significantly reduce radar disruption [13].

Radar System Modifications

A majority (80%) of long-range radar infrastructure in the interior of the U.S. was designed in the 1950s, and the remaining systems were designed in the 1970s. Updating radar system technology can reduce wind turbine interference [13]. In the 1990s, many of the coastal and border regions, including a location in Empire, Michigan, were upgraded to newer, more advanced radar systems [14; 15]. Improvements can include updating the software (how the system interprets data) or hardware (replacing out-of-date equipment).

West Michigan communities might look to coastal Massachusetts for an example of how updates minimized a wind farm's effect on radar. The FAA determined that the proposed Cape Wind project's 130 wind turbines would be detected by and clutter the airport radar systems in the area [16]. The motion of the turbine blades and the out-of-date radar system was believed to intensify the interference. To mitigate the potential interference, the developer of Cape Wind project agreed to pay \$1.5 million to upgrade the radar system around the project site. In addition, the developers put an extra \$15 million into escrow in case these upgrades were not sufficient, providing funds to install a more state-of-the-art system if needed [17].

Illumination of Wind Turbine Structures

The FAA also requires that wind turbines be properly illuminated so that airplane pilots can identify and avoid these structures [18]. Offshore turbines must be visible not only to pilots in the air, but also mariners navigating on water. In daylight, both onshore and offshore wind turbines do not require lighting as long as the tower and components are painted white. The FAA and U.S. Coast Guard (USCG) consider white-colored turbines to be the most effective early warning technique for both pilots and mariners [19]. This section summarizes the policies for illumination of onshore and offshore wind turbines at night and the potential effects of lights on the surrounding community.

Onshore Turbines

In 2005, the FAA assessed the lighting patterns of 11 wind farms in the United States [18]. At the time, there were no standard regulations for properly installing lights within a wind farm and wind energy developers had trouble obtaining an approved lighting plan. Additionally, different lighting schemes, even for wind farms located only a few miles apart, often led to confusion among pilots [19]. These concerns led the FAA to set lighting standards for wind farms in 2007.

The FAA determined that only some wind turbines in a wind farm need lights, and it established guidelines for arranging lights. For example, illuminating the boundary of a wind farm is essential, turbines taller than perimeter turbines must have lights, and there should be no more than 0.5 miles between illuminated structures within a wind farm. The FAA recommends that wind energy developers use flashing red (FAA L-865) bulbs that are synchronized to flash at the same time on every lit turbine [18]. Lastly, the FAA recognized that lighting requirements vary depending on terrain, proximity to airports and communities, and wind turbine configurations. The following diagrams (Figure 4) illustrate the FAA's

Updating the software and hardware of radar system technology around wind farms can mitigate potential wind turbine interference.

In 2007, the FAA set lighting standards for wind farms, suggesting developers use synchronized flashing red bulbs and noting that requirements vary depending on wind farm characteristics.

recommendations for lighting three common wind farm configurations — linear, grid and cluster. All turbines located outside a specific configuration would need to be illuminated [18].

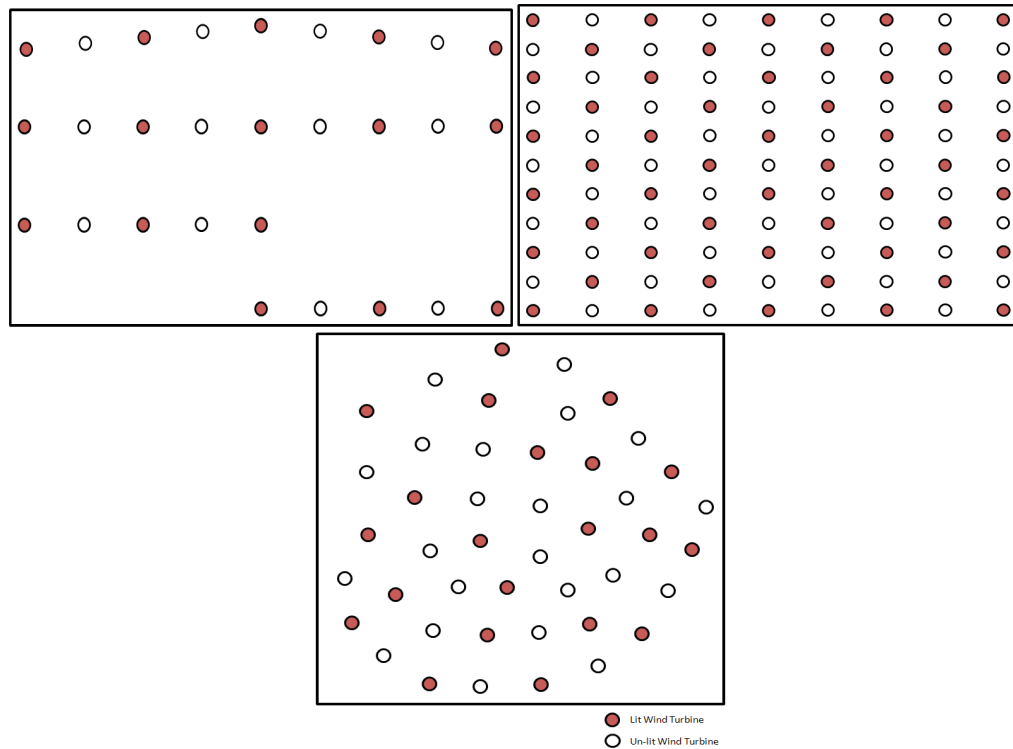


Figure 4: Schematics of the FAA's lighting recommendations for a linear, grid and cluster configured wind farm, respectively.

Offshore wind farms are subject to the same FAA lighting guidelines as onshore, but developers must also work with the U.S. Coast Guard to ensure safe marine navigation.

Offshore Wind Turbines

Onshore and offshore wind farms are subject to the same FAA lighting guidelines. However, offshore wind farm developers must also work with the U.S. Coast Guard (USCG) to ensure that the turbines are sufficiently marked for safe marine navigation [20].

The USCG mandates that every offshore wind turbine tower be painted yellow from the maximum water level to 50 feet up the turbine tower, as illustrated in Figure 5, and be equipped with a retro-reflective device⁴. The USCG also requires that wind turbines have lights that are mounted on access platforms approximately 35 feet above the water, which are distinct from the FAA safety lights that are placed at the top of the turbine tower (on the nacelle) [2].



Figure 5: Offshore wind turbine with base painted yellow up to 50 feet above the highest astronomical tide (Photo: DONG Energy).

⁴A retro-reflective device is an apparatus that reflects light back to its source with minimal scatter.

The Cape Wind project is the only FAA-and USCG-approved lighting plan for an offshore wind farm in the U.S., and includes specific requirements for light placement, intensity, color and timing.

The visual impact of wind farm safety lighting is one of the most commonly cited complaints by area residents, but new innovations can mitigate this impact while maintaining safety levels.

The USCG requires that each “Significant Peripheral Structure” be illuminated in a unique way. For wind farms, this applies to turbines located at the corners of the wind farm and other key turbines located on the array’s perimeter. The lights for these turbines should be synchronized and viewable to mariners for 4 nautical miles⁵ in all directions. The distance between these uniquely lighted turbines should not be more than 3 nautical miles. Other turbines that are located on the perimeter of the wind farm should be illuminated with a distinct, lower intensity, flashing yellow light that is visible at 2 nautical miles. USCG will determine if other turbines located within the perimeter of the wind farm also require marine navigation lights [20].

There has only been one FAA-and USCG-approved lighting plan for an offshore wind farm in the United States: the proposed Cape Wind project in Massachusetts. The lighting plan includes very specific requirements for light placement, intensity, color and timing. Each wind turbine will have at least four lights: two on top of the tower to ensure visibility from the air and two on the access platform 35 feet above the water to alert mariners at sea. All of the lights will flash at a rate of 20 flashes per minute. The wind turbines located on the perimeter of the wind farm will be illuminated brighter than those in the interior and will be synchronized to flash together. The turbines in the interior will have lower intensity lights that flash randomly, to help mariners and pilots know when they have entered the wind energy installation [2].

For visibility from air, certain turbines on the perimeter will have two medium intensity white warning lights that are lit during the day and two medium intensity red lights for night. Other turbines in the wind farm will be equipped with two low intensity red bulbs that will be lit day and night. For marine safety, all Cape Wind turbines will have two amber, USCG-approved Aids to Navigation lights mounted on the turbine’s access platform. In addition, the corner turbines will be fitted with foghorns, which will be audible at 1/2 nautical miles to assist mariners with navigation in foggy conditions. These sound devices will be equipped with sensors so they will only be in operation in times of decreased visibility [2].

Minimizing Visual Impacts

Safety lighting is essential for air and water traffic, but the lights can affect the surrounding communities. The visual impact of wind farm safety lighting is one of the most commonly cited complaints by area residents [21]. As long as they are painted white, wind turbines are usually required to be lit only at night when there is less visible context, and thus, lights are more likely to be seen in isolation [32]. Though flashing red lights are used as opposed to white, the red still differs greatly from typical colors of the night landscape and the flashing makes the lights more prominent [32]. Outdoor areas such as natural parks or primitive camping areas where natural landscape settings are expected are of most concern in terms of minimizing impact [32]. Some companies are now offering innovations that mitigate the visual impact of wind turbine lighting, while maintaining the required level of safety for pilots and mariners. For example the Obstacle Collision Avoidance Systems (OCAS) was introduced in 2010. The system uses a low frequency radar system attached to select wind turbine towers to detect approaching aircraft from all directions (Figure 6). The lights turn on only when an aircraft approaches the wind farm. Additionally, an audio warning is broadcast to alert approaching pilots [22]. This technology is presently the only wind turbine lighting solution that

⁵1 nautical mile=1.15mile

The U.S. Army Corps of Engineers identified five potential impacts of an offshore windfarm on marine navigation as related to collisions and water accessibility for fishing and boating or other commercial purposes.

The distances between offshore wind farm turbines should allow vessels to easily maneuver through the wind farm if they maintain a relatively straight path.

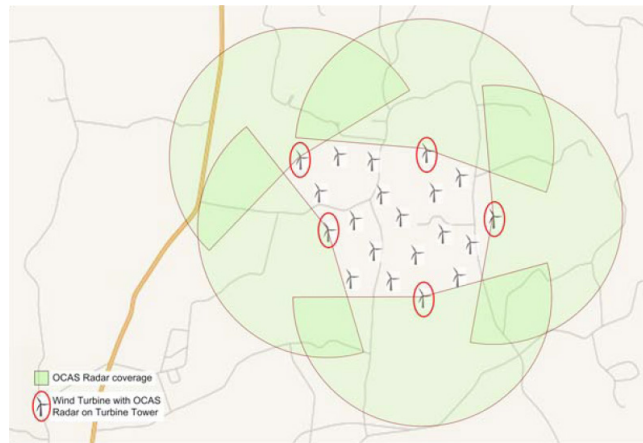


Figure 6: Diagram illustrating the radar coverage for wind farms equipped with the Obstacle Collision Avoidance System.

complies with FAA requirements and is approved by the International Dark Sky Association, a group interested in minimizing night light pollution. OCAS is becoming more popular around the world and is currently being used at wind farms in Sweden and Canada.

Offshore Wind Farms and Marine Navigation

Large offshore wind energy projects can stretch across vast areas of water. In addition to concerns about collisions, fishermen and sailors often worry that offshore wind farms will restrict the amount of water accessible for fishing and boating or for other commercial purposes [23]. The U.S. Army Corps of Engineers has identified five effects that an offshore wind farm will have on marine navigation [25]. This section briefly summarizes each of the following issues, with references to the proposed Cape Wind project in Massachusetts as appropriate:

- Vessel movement
- Vessel anchoring
- Risk of collision
- Ice buildup
- Proposed Aids to Navigation

Vessel Movement

Most offshore wind farms are arranged in a regular grid pattern. The distances between turbines should allow vessels to easily maneuver through the wind farm if they maintain a relatively straight path [25]. However, if constructed in shallow waters, large vessels, such as coal freighters, may not be able to navigate through a wind farm without risk of hitting a turbine foundation.

For the proposed Cape Wind project, the turbines will be arranged in parallel rows with about 0.6 miles between rows and 0.4 miles between turbines within a row. To visualize these distances, five S.S. Badger car ferries (410 feet long) could be placed stern to bow between the closest wind turbines and still have 137 feet to spare. Boats the size of the S.S. Badger navigate through the harbors of West Michigan and would easily be able to navigate through a wind farm of this size and spacing.

The U.S. Coast Guard has the authority to designate areas as off-limits or as limited access areas. In the United States there are approximately 240 limited access areas, many of which still allow for the passage of commercial and recreational traffic

The USCG determines no or limited access on a case-by-case basis; there are currently about 240 limited access areas in the U.S., many of which still allow passage of commercial and recreational traffic.

The two ways in which a boat might collide with a wind turbine include a mast contacting a blade or the boat colliding with the tower. Risk of collision depends on the type of boat and its use within the wind farm.

with appropriate authorization. The determination of no or limited access is made by the Coast Guard on a case-by-case basis [20]. They have not designated the Cape Wind project location as a limited access area. In the United Kingdom, offshore wind farms are designated as limited access areas during the construction phase to ensure boat safety, with a 1640.42 ft restriction zone around the area. During operation, offshore oil production platforms have a 1640.42 ft restricted access safety zone, but it's expected that wind turbine restrictions will be relaxed and given a 164.04 ft safety zone around each tower in British waters [26]. However, in the Netherlands, Germany and Belgium, the 1640.42 ft construction phase safety zone continues to apply during operation [33].

Vessel Anchoring

Wind turbines are connected to each other via cables that are typically buried under 6 feet of sediment. The USCG has looked at the risks associated with anchoring a boat within a wind farm. How deep an anchor penetrates the bottom sediment depends on the anchor type, weight, and sediment type (e.g., clay, sand, silt). For example, a 2,000 pound Stockless anchor with a 34 inch fluke⁶ will penetrate a sandy bottom to a depth of 3 feet. A 10,000 pound Danforth anchor with a 7.2 foot fluke would penetrate a sandy bottom to a depth of 4 feet.

In either case, anchor penetration does not come close to the buried submarine cable, which is underneath 6 feet of sediment. Anchoring a small boat within a wind farm poses no risk to the buried cables, however, boat operators should anchor their boat far enough from the turbines so that their boat cannot swing into one [25].

Risk of Collision

There are many types of boats that use the Great Lakes, including enormous freighters and small fishing boats. The risk of collision will depend on the type of boat and its use within the wind farm. There are two possible ways that a boat might collide with a wind turbine: a mast could come in contact with a blade, or the boat could collide with the tower. The following section examines collision risk associated with three different boat sizes using specific existing Great Lakes boats as examples.

- ***Motor Vessel Paul R. Tregurtha***

The Motor Vessel Paul R. Tregurtha is currently the largest boat on the Great Lakes at 1,013 feet. This coal freighter is 105 feet wide, has a draft of 56 feet, and a top speed of 15 knots (17.3 mph). This boat has the capacity to carry 68,000 tons of coal and can weigh up to 76,948 tons when fully loaded [27].

If the Tregurtha were to collide with a wind turbine there would be considerable damage to the turbine, but likely minimal damage to the vessel itself. The turbine could absorb all the kinetic energy from a collision and the ship would continue moving forward, pushing on and ultimately toppling the entire turbine [28].

However, there is currently no documented incident of a large freighter colliding with a wind turbine anywhere in the world and the odds of this happening are low. A study conducted by the European Union estimated that a ship the size of

⁶A **fluke** is the triangular blade at the end of an arm of an anchor, designed to catch in the ground.

Tregurtha might collide with one of the existing offshore wind turbines once every 200 years. Increasing safety measures, including carefully locating a wind farm away from major shipping lanes and properly marking the wind farm in accordance with FAA and USCG requirements, could further reduce the risk [29].

- **Research Vessel Laurentian**

The Research Vessel Laurentian is a NOAA research vessel that is 80 feet long, 22 feet wide, weighs 129 tons and has a top speed of 10 knots (11.5 mph). The Laurentian usually operates between March and December, collecting water quality and other scientific data throughout the Great Lakes [30].

There are two types of collisions that ships like the R/V Laurentian should be concerned about: head-on and drift induced. As part of Cape Wind's permitting process, the U.S. Army Corps of Engineers conducted a navigational risk assessment on various types of vessels that might frequent the proposed wind farm. The Corps found that any boat cruising at 15 knots (17.26 mph) or less and weighing less than 1,500 tons would not topple a wind turbine. A collision between a wind turbine and a boat the size of the Laurentian would damage the boat and cause the turbine to deform somewhat. The amount of damage would depend on the speed and weight of the boat and the angle of the collision [25].

- **Sailboats and Other Small Boats**

In addition to the risk of collision with wind turbine bases, sailboat operators should assess the position of their mast in relation to the turbine's blades. The potential for contact will depend on the tower height, the size of the blades and the size of the sailboat [25].

For the Cape Wind project, sailboats that travel within 22 feet of a turbine's base and have a mast that reaches 74 feet above the water line could contact a turbine blade. A wind turbine could also block the view of a sailboat or other small boat. The time that a boat would be out of sight would depend on the size and angle of the boat and the speed of the boat and the viewer.

Around Lake Michigan, some people are concerned that an offshore wind farm could interfere with popular sailboat races, such as the Chicago to Mackinac. This 333-mile race has been running since 1898, and a wind farm off the coast of West Michigan could force participants to deviate from their preferred course. The largest boat registered for the 2011 Chicago to Mackinac race was an 86-foot Max Z86 racing yacht called Windquest⁷. This boat can reach speeds of up to 24 knots, has a draft of 14 feet, and a mast height of over 100 feet. Assuming recreational access is allowed within an offshore wind farm, boats of this size should easily navigate through the turbine towers, however, their masts could collide with the blades of a turbine.

Ice Buildup

In cold weather environments like West Michigan, ice can form in the calm waters around the base of wind turbines or build up on turbine blades. Ice around the base could restrict boat access, and ice on the blades periodically flies off and these ice chunks could collide with a nearby boat [31]. However, there is very little boating

⁷As of June 2, 2011. Accessed via Chicago Yacht Club's webpage at <http://www.cycracetomackinac.com/entries.cfm/>

The potential for a sailboat or other small boat's mast to contact a turbine's blade will depend on the tower height, size of the blades and the size of the sailboat.

Ice could form in the calm waters of Lake Michigan around the base of wind turbines or build up on turbine blades, restricting boat access or risking ice thrown from blades colliding with nearby boats.

activity on Lake Michigan during the winter months so the risks to boaters are minimal.

On average, ice will cover about half of Lake Michigan's surface during a typical winter. Most of southern Lake Michigan remains free of ice because of deeper waters and milder water temperatures. The icing of wind turbines in Lake Michigan should not affect marine navigation, but it could affect the design, safety and cost effectiveness of wind projects, which is discussed in a companion issue brief, Offshore Wind Power: Environmental Benefits, Challenges and Consequences.

Offshore wind farm turbines can serve as a point of reference to sailors and thus would be considered an Aid to Navigation by the USCG.

Aids to Navigation

An offshore wind farm would be considered an Aid to Navigation by the USCG, meaning the turbines can serve as a point of reference to sailors. Individual wind turbines and the perimeter of the wind farm will be represented on updated NOAA navigation charts [2]. Most wind farms are arranged in a grid configuration and the turbine towers can be marked with an alphanumeric system. A numbering system could help mariners identify their current position within a potentially vast wind farm area. Each wind turbine will also have a safety line attached to its base that boaters can tie up to in case of an emergency. Additionally, there is an access ladder for people in the water to climb up in times of distress. However, under normal circumstances the USCG prohibits boaters and swimmers from mooring or climbing up wind turbine platforms.

Conclusion

Navigation is a critical part of traveling by plane, boat or car. Pilots and sailors rely on maps, GPS, radar and visual cues to guide them, and wind turbines can affect the reliability of these tools. For example, wind turbines within the line of sight of a radar system will clutter the radar signal. Radar interference can be reduced by locating wind farms away from sensitive radar systems, using special materials for the construction of turbine blades, and updating the software and hardware of nearby radar systems. Wind energy developers must work with agencies such as the National Weather Service and the Department of Defense to minimize potential radar interference.

The USCG works closely with wind energy developers to evaluate, communicate and minimize any potential risks to boaters.

Because of their height, the Federal Aviation Administration has determined that wind turbines are a hazard to aircraft. Wind turbines that are painted white typically do not need to be lit during the day, however, at least some wind turbines in a wind project must use lights at night. These air safety lights are located at the top of a turbine tower and can be a concern for nearby homes. New technologies that activate lights only when aircraft approach could minimize the visual impact of turbine lights in the future.

Although there are currently no offshore wind farms in the U.S., a project has been approved for construction in Massachusetts. In addition to air safety lights, offshore wind turbines are required to have special features to aid marine navigation, including specific lights, unique paint colors, fog horns, and emergency mooring lines and access ladders.

Offshore wind farms occupy vast areas of water, which raises concerns about whether sailing, fishing and commercial ship travel will be restricted near the turbines. Offshore wind farms could influence vessel movement and anchoring, and create a risk of collision for boaters. The turbines are typically arranged in a regular

grid pattern with large distances between them, allowing most vessels to navigate among the towers. Turbines can block the view of boats and the blades could hit the mast of a tall sailboat. The U.S. Coast Guard works closely with wind energy developers to evaluate, communicate and minimize any potential risks to boaters.

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