The Environmental Case for Wind Power in Wisconsin

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Executive Summary

In the coming years, Wisconsin will need to make some difficult choices about its electricity sources.

The Public Service Commission state's electricity demand is expected to grow by 2.3 percent a year for the next decade. Efficiency measures can mitigate this demand growth, but additional power generation facilities will also be necessary—both to satisfy this increased demand and as replacement power as dirty or unsafe plants are retired.

Generating power by using fossil fuels or nuclear power imposes unbearable costs on our environment, our health, and our economy. Considering these costs reveals one clear path for Wisconsin: the state must tap into clean, sustainable energy resources such as wind power, rather than increasing our dependence on dangerous, polluting power sources such as coal, natural gas and nuclear-powered plants.

Global Warming

Global warming, caused by the release of greenhouse gases from burning fossil fuels, is the most severe impact of our current energy path. If emissions of greenhouse gases are not dramatically curtailed, life in Wisconsin will be significantly altered within the next century.

- Some scientists have estimated that global climate change could lead to a three to eight foot drop in Lake Michigan
- Global warming will cause significant disruption of ecosystems and thus wildlife habitats. Changing vegetation will alter wildlife population size, density, and behavior. Shifts in habitat may force as many as 35 species of birds to change their ranges to exclude Wisconsin.
- Warming is already occurring: temperatures in the past century have risen by an average of one degree.
- In 2003, Wisconsin's coal-fired power plants released an estimated over 123.6 million tons of carbon dioxide—emissions equivalent to four times the number of cars on Wisconsin's roads.

Air and Water Pollution

Fossil fuels burned to produce electricity also contribute to Wisconsin's and the region's air and water pollution problems, threatening the health of residents and impacting our quality of life.

- During 2003, the eight-hour health standard for ground-level ozone ("smog") was exceeded 80 times in Wisconsin, and the U.S. Environmental Protection Agency has designated ten counties in Wisconsin as violating health standards for ozone. Ground-level ozone, which is partially caused by emissions of nitrogen oxides (NOx), can lead to asthma, bronchitis, increased susceptibility to bacterial infections and other respiratory problems.

- Acid rain, the result of NOx and sulfur dioxide (SO2) emissions, kills forests and damages aquatic ecosystems. In Wisconsin, 37 percent of our lakes are acidic or sensitive to acid rain.
- Mercury from coal power plants has contaminated the state's lakes and streams, leading to a statewide advisory on fish consumption.

Nuclear Hazards

Nuclear power plants are another environmental crisis in the making. Wisconsin's aging plants generate tons of radioactive waste that will remain lethal for centuries.

- Exposure to radiation from nuclear waste can cause serious health problems, including cancer, developmental disorders, hereditary disease, accelerated aging, and immune system damage.
- Wisconsin's two nuclear power plants are projected to have 1327 metric tons of spent fuel on site by 2011. These facilities have no safe storage options for their waste, and aging equipment at the plants increases the odds of an accident that will release waste.
- An accident involving radioactive material—whether due to mishandling, equipment fatigue or a terrorist act—could endanger thousands of people.
- Evacuation plans are woefully inadequate, so the growing populations of Kewanee and Manitowoc counties are vulnerable to the release of nuclear material from an accident or terrorist attack.

Wildlife and Habitat Destruction

Statistics about wildlife deaths related to different energy sources indicate that wind power, a renewable energy source, has a more modest impact on wildlife and habitat than do coal, natural gas, or nuclear power.

- Mining for coal or for uranium destroys vast areas of habitat. A single mine can strip up to ten square miles, disrupting individual animals and in some cases entire species. Coal mining in Tennessee threatens the habitat of the Cerulean warbler, a species that is in precipitous decline.
- One study of wind turbines indicates an average of 2.3 avian fatalities at each turbine each year, for a total of 10,000 to 40,000 birds killed per year nationwide. As more wind farms are erected in the United States, new research continues to discover ways to design and site these facilities to minimize wildlife disruption from wind farms.

Wind: The Least Damaging Choice

Wind has great potential for generating electricity that we have only begun to tap. While concerns about wind power's impacts on vistas and birds and more recently on bats have slowed its development, the impacts are minor when compared to the harm caused by the mining and burning of coal and natural gas, or by nuclear power. Wind power does not contribute to global warming, and produces no air pollution or wastes. For these reasons, wind power, in combination with energy efficiency measures, constitutes one of the few sources with which to reasonably meet Wisconsin's growing electricity demand.

Introduction

Wisconsin's landscape offers gently rolling hill that are dotted with barns and farm fields. Our state boasts amazing wildlife, from fish to wolves to black bears. The coasts of Lake Michigan and Superior offer beautiful open views of waters. Protected wetlands host hundreds of thousands of migrating birds, harbor other wildlife, and provide a place for bird watching. Bays and estuaries are home to fish and shellfish, and support commercial fishing.

Wisconsin's farms and lakeshores also have substantial wind resources. Wind turbines erected in areas that receive strong winds, both along the coast and throughout the southwest and northwest, have the potential to generate non-polluting electricity to help meet Wisconsin's growing demand for energy.

Adding windmills to this natural vista might seem like an undesirable thing to do because the turbines will disrupt unbroken views and are another artificial structure along the coastline. There has also been great concern about windmills adverse impacts on bird and bat populations. But windmills might be the salvation of Wisconsin.

The number one threat to Wisconsin and all its wildlife is global warming. Powering modern society by burning fossil fuels has measurably increased the atmospheric concentration of carbon dioxide and other gases that trap solar radiation near the earth's surface. This has resulted in rising global temperatures, leading to changes in denser algae blooms in our lakes, changes in climate that will necessitate growing different crops, changes in tree species that could affect our forests and the wildlife that depend on them.

No one can fully predict the results of global warming on Wisconsin's farms and lakes in 10 years or 50 years but the impact will be felt in our economy as well as our natural environment.

Considerable damage has already been done. But we have an opportunity to try to minimize future damage. Ceasing to produce carbon dioxide today will not halt global warming, but it will reduce the severity of the change.

Given the significance of the threat to our environment, all Americans must look long and hard at the choices we have for power generation to meet anticipated future need. If the choice is between two polluting forms of power generation, then we must pick the lesser polluter. And if we can choose non-polluting power sources, such as efficiency and wind and solar power, then we must not accept sources that do great harm to our environment.

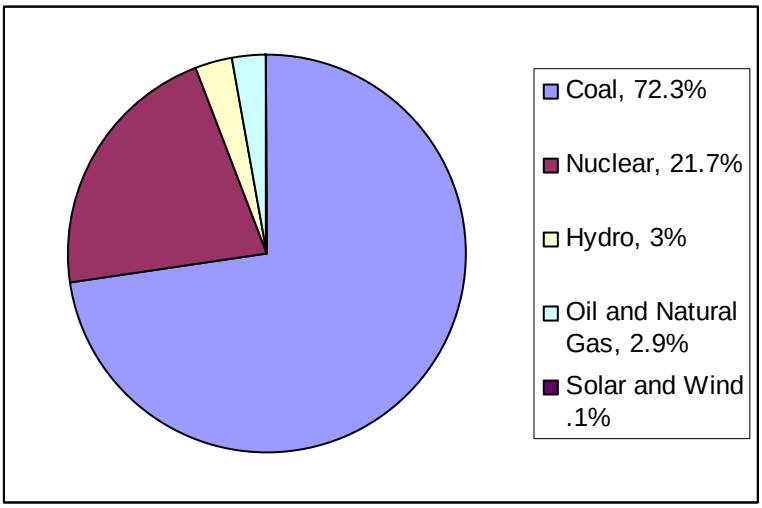
Here in Wisconsin, we have such a choice. We have the capacity to meet much of our future need through wind power, which is emission-free and can be produced with minimal impacts on the natural world.

Wisconsin alone cannot stop global warming. But in concert with states across the country in which progress is being made toward reliance on cleaner energy sources, Wisconsin can help lead the way toward creating the infrastructure for a clean energy future.

Wisconsin's Electricity Demand and Production

Wisconsin consumes 68 million kilowatt-hours (kWh) of electricity each year to heat homes, light offices, and run factories.[1] Of the electricity produced in Wisconsin, 72.3 percent comes from coal and 21.7 percent from nuclear. Less than 1 percent comes from clean, renewable sources such as solar, biomass from clean sources, and wind power.

Figure 1. Source of Electricity Generated in Wisconsin[2]



According to the Public Service Commission, Wisconsin's energy demand is expected to grow by 2.3% a year for the next three years and then 2% per year. Based on these state projections, statewide electricity demand will reach 85.12 million MWh in 2013.

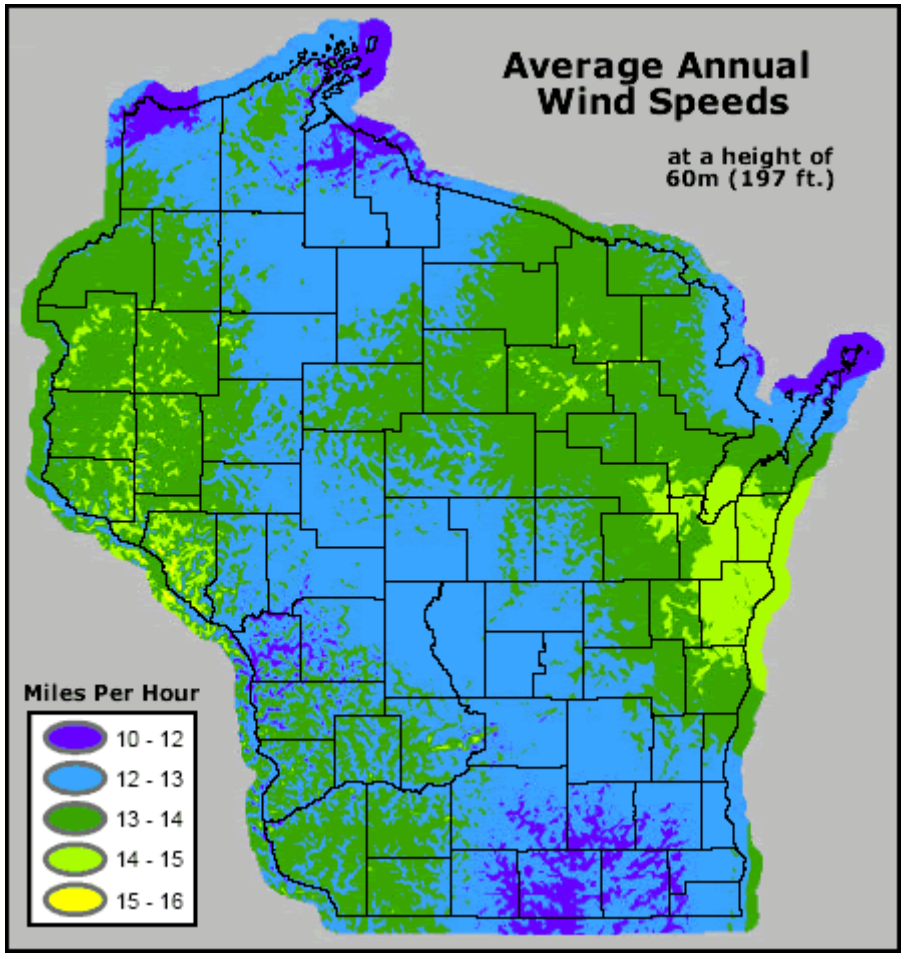
Some of this new demand can be met cheaply and cleanly through conservation—using less energy—and efficiency—reducing the amount of energy necessary for producing a given good. Conservation and efficiency have the effect of increasing supply without imposing any negative consequences. However, these measures cannot entirely eliminate the need for new electricity generation facilities, whether they are built to meet new demand or replace antiquated sources of power. Wisconsin and the rest of the country need to shift to cleaner sources of power.

The state has taken the first steps to ensure that future electricity generation is cleaner. In 1999, Wisconsin adopted the state's first renewable portfolio standard (RPS), which would reduce the amount of air pollution, acid rain, and other harmful effects that result from the state's current dependence on dirty power sources by requiring power companies to generate 2.2 percent of our energy from clean, renewable sources. In 2003, Governor Doyle announced a Task Force to make recommendations about how Wisconsin could generate 10 percent of its electricity by 2013. The Task Force on Energy Efficiency and Renewables agreed on a goal of generating 10 percent of the

state's energy by 2015 and to have the state government lead the way by purchasing 20 percent of its energy from renewable sources by 2010.

One important renewable energy source for Wisconsin is wind power, most accessible in the and southwest northwest corner of the state, along the coast and offshore. Wisconsin's onshore resources are concentrated along the coast and along ridges in the northwest corner of the state, as seen in figure 2. According to the U.S. Department of Energy, assuming that wind turbines are not erected in urban areas or on environmentally sensitive land, Wisconsin could generate over 6.7 million MWh of electricity from wind power.[3]

Figure 2. Map of Wisconsin's High Wind Energy Potential Regions[4]



A Note on Units

Megawatts (MW) are the standard measure of a power plant's generating capacity—how much power it could produce if operating at full speed. Utilities also measure their ability to supply demand on the grid at any one time in terms of MW. One MW equals 1,000 kilowatts (KW). One thousand MW equals one gigawatt (GW).

Power plant output and electricity consumption over a fixed length of time are measured in terms of megawatt-hours (MWh), the total amount of electricity generated or consumed during one hour. For example, a 50 MW power plant operating at full capacity for one hour produces 50 MWh of electricity. If that plant operates for a year at full capacity, it generates 438,000 MWh of electricity (50 MW capacity x 8,760 hours/year).

Most plants do not operate at full capacity all the time; they may be shut down for maintenance or they may be operated at only part of their maximum generating potential because their power is not needed or their power source (such as wind) is not available. The actual amount of power that a plant generates compared to its full potential is reported as its capacity factor. Thus a 50 MW plant with a 33 percent capacity factor would produce 144,540 MWh of electricity in a year (50 MW x 8,760 hours/year x 33% capacity factor).

A facility's generating potential sometimes is measured in average MW (aMW), the amount of generation averaged over all the hours of the year. A 50 MW plant with a 33 percent capacity factor will have a potential of 16.5 aMW (50 MW x 33% capacity factor).

Environmental and Public Health Impacts of Energy Generation

All sources of electricity have an impact on natural resources and the environment. The type and level of impact varies greatly between different sources. The following is a discussion of the environmental impacts of coal, natural gas, nuclear power and wind power as electricity sources and a comparison of the ecological problems they cause.[5]

Global Warming

Perhaps the most dangerous consequence of our current energy production methods is the alteration of our global climate. Emissions from the burning of fossil fuels like coal and natural gas are the leading cause of global warming. Fossil fuel power plants produce 39 percent of all the carbon dioxide generated in the United States.[6] Wind power does not produce any carbon dioxide or greenhouse gases.

Since the advent of fossil fuel technology, the atmospheric concentration of carbon dioxide (CO2), the most prevalent greenhouse gas, has increased by 30 percent.[7] As a result of past and continuing CO2 emissions, the average temperature of the earth's surface is expected to rise by three to ten degrees by 2100.[8] In Wisconsin, we could see a four degree increase in temperature in winter, spring and fall. Precipitation is projected to increase by fifteen to twenty percent in winter, summer, and fall.[9]

The effects of such warming are potentially catastrophic. Globally, warming is expected to alter ocean currents, cause devastating droughts, floods and violent storms, contribute to wildfires, and spread tropical diseases to temperate climates.[10]

Human Health Risks

Higher temperatures will harm Wisconsin residents' health. A study projects that a three degree increase in temperature could almost double heat-related illness in Milwaukee during the summertime months.[11] The concentration of ground-level ozone, which worsens asthma and reduces lung function, will increase as temperatures rise.[12] Ozone levels already exceed public health standards in ten counties in Wisconsin and present a severe public health threat. Further increases will sicken even more Wisconsin residents.

Global warming could also lead to greater exposure to diseases carried by mosquitoes and other insects. Global warming could increase average temperatures and precipitation in Wisconsin which would expand the mosquito population. La Crosse encephalitis, which can lead to seizures and comas, has already been found in mosquitoes in Wisconsin and the number could grow if temperatures continue to rise. Other serious illnesses such as yellow fever and dengue fever have already been found in mosquitoes as far north as Chicago. [13]

Wildlife Disruption

Global warming will cause significant disruption of ecosystems and thus of wildlife habitats.[14] Changing vegetation will alter wildlife population size, density and behavior.

Currently vulnerable species will be at especially high risk. In the United States, 56 bird species, 42 mammal species, 28 reptile species, and 25 amphibian species are at risk of extinction.[15] Global warming will increase the stresses on these populations.

Experts agree that ecosystems and wildlife will not be capable of accommodating the full scope of the effects of global warming.[16] Different components of an ecosystem will respond differently. For example, though some birds will begin to migrate earlier in the year and hibernating animals will emerge earlier from their hibernation, the timeline of availability of their food sources—insects, flowers, and berries—may not change at all, leaving the birds and animals without food.[17] Another warming-related change, already imperiling animals in some locations, occurs when different ecosystems respond differently to global warming. This is of particular significance when a species relies on different ecosystems for summer and winter habitat. American robins now arrive two weeks sooner at their high-elevation summer habitat in the Rocky Mountains than they once did, likely as a result of a shortened winter at the birds' low-elevation wintering grounds. This changed timeline creates stress on the birds when they arrive at their summer habitat to find it still covered in snow.[18]

Over 30 species of birds may disappear from Wisconsin as they follow their shifting habitat. Though their present ranges include Wisconsin, the birds will be forced to leave as global warming makes ecosystems within the state unable to support those species.[19] (See Table 1.)

Table 1. Bird Species That May Disappear from Wisconsin Due to Global Warming[20]

Olive-sided Flycatcher.	Blackburnian Warbler
American Redstart	Northern Waterthrush
Kentucky Warbler	Connecticut Warbler
Mourning Warbler	Canada Warbler
Clay-colored Sparrow	Lincoln's Sparrow
Swamp Sparrow	White-throated Sparrow
Dark-eyed Junco	Brewer's Blackbird
Purple Finch	Pine Siskin
Evening Grosbeak	Yellow-bellied Flycatcher
Alder Flycatcher	Least Flycatcher
Boreal Chickadee	Red-breasted Nuthatch
Winter Wren	Sedge Wren
Blue-headed Vireo	Golden-winged Warbler
Tennessee Warbler	Nashville Warbler
Northern Parula	Chestnut-sided Warbler
Magnolia Warbler	Yellow-rumped Warbler
Black-throated Green Warbler	Cape May Warbler
Black-throated Blue Warbler	

Seabirds are also very vulnerable to global warming. Small changes in ocean temperature may influence seabird reproduction rates.[21] For example, the productivity of red-legged and black-legged kittiwakes responds measurably when ocean temperatures change by as little as one degree Celsius.[22] Short-term changes in the Pacific Ocean due to cyclical cooling and warming of the ocean have altered food availability and thus bird abundance.[23] Global warming will have a much greater impact.

Global warming will harm marine mammals also. Whales will have less food available as warmer ocean temperatures reduce the amount of zooplankton, such as krill, which is a major food source. Seals and sea lions also are vulnerable to temperature-related disruptions of their food supplies. For example, during the 1997-1998 El Niño event that warmed the eastern Pacific, hundreds of Galapagos seals and sea lions and California sea lion pups died of starvation.[24]

Contributions of Different Electricity Sources to Global Warming[1]

Coal

Coal-fired power plants are major producers of greenhouse gases in Wisconsin. The state's coal-fired power plants released 123.6 million tons of global warming gasses in 2003.[25] This is equivalent to the carbon emissions from over 22.6 million cars, or about four times the number of the vehicles on the road in Wisconsin.[26] While the emissions from coal-fired power plants in Wisconsin are significant, those numbers do not account for the energy Wisconsin receives from coal-fired power plants in neighboring states. Nationally, coal-fired power plants produce almost 40 percent of the country's global warming pollution.[27]

Nuclear Power

Nuclear power plants contribute relatively little to global warming. Their greatest impact, discussed later in this report, is in the long-lived radioactive waste they produce and the health threat they present to Wisconsin residents.

Wind

Electricity produced by wind energy does not contribute to global warming.

[1] We did not include data about natural gas plants in this report because currently less than three percent of Wisconsin's electricity comes from natural gas. Natural gas while better than coal still contributes to global warming.

Health-Threatening Air Pollution

Pollution released during the production of electricity from coal and natural gas-fired power plants harms people of all ages. It can cause asthma in children, diminished attention capacity in youths, and chronic bronchitis in adults. For people made vulnerable by other illnesses, air pollution can also cause fatal respiratory and cardiovascular complications. Electricity from wind power produces no air pollution.

The Chemistry of Air Pollution

Ground-level ozone, commonly known as smog, is the nation's most significant air contaminant. During 2003, the eight-hour health standard for ground-level ozone was exceeded 80 times in Wisconsin.[28] Over 2.1 million people in Wisconsin live in areas where ozone levels are high enough to damage human health. As a result, the U.S. Environmental Protection Agency has designated ten Wisconsin counties, Door, Kewanee, Manitowoc, Sheboygan, Ozaukee, Washington, Milwaukee, Waukesha, Racine, and Kenosha as violating ground-level ozone standards.[29]

Chemically identical to the stratospheric ozone that protects us from the sun's harmful radiation, ground-level ozone is a colorless, odorless gas. It forms when nitrogen oxides (NOx) mix with volatile organic compounds (VOCs) in the presence of sunlight. Conventional fossil-fuel plants contribute enormously to ground-level ozone, emitting 33 percent of the nation's NOx emissions.[30]

Ozone

Inhaling ground-level ozone can be extremely dangerous. The ozone gas inflames and burns through sensitive lung tissue. The swelling and associated scarring decrease oxygen intake and can lead to asthma, bronchitis, emphysema, increased susceptibility to bacterial infections and other respiratory problems. High concentrations of ozone can restrict the activity of even the healthiest individuals. For at-risk populations, such as children, the elderly, outdoor workers, and people with respiratory problems, ground-level ozone poses an immediate and severe health threat. Ozone pollution in the Eastern United States contributes to more than 6 million asthma attacks and 159,000 respiratory emergency room visits each year.[31] In Wisconsin, the American Lung Association estimates that 133,293 children with asthma live in the ten counties exceeding air quality standards for zone.[32]

Sulfur Dioxide

Sulfur dioxide (SO2), another byproduct of energy production and use, is a component of fine particulate matter, or "soot." Health consequences of inhaling fine particulate matter include asthma, cancer, bronchitis, and other respiratory diseases. Soot also can cause premature death. As with ozone, the inhalation of fine particulate matter disproportionately affects children, the elderly, and those with respiratory problems. The U.S. EPA estimates that fine particle pollution from the nation's power plants cuts short the lives of over 30,000 people each year.[33] Fossil-fuel power plants emit 70 percent of national sulfur dioxide emissions and 28 percent of all particulate matter.[34] In Wisconsin, dirty power plants are responsible for 67.7 percent of statewide SO2 emissions.[35]

Mercury

Power plants also release mercury and other heavy metal air toxics. Coal-fired power plants in Wisconsin emitted nearly 2615 pounds of mercury in 2002.[36] Less than one gram of mercury deposited into a 20-acre lake is enough to make the fish there unsafe to eat.[37] As a result, Wisconsin has issued statewide advisories on freshwater fish consumption.

Once in the air, mercury undergoes photochemical oxidation and forms oxidized mercury. Oxidized mercury is deposited to land, lakes, rivers, and streams by precipitation, where it reacts with bacteria to form methyl mercury, the form most toxic to humans. Methyl mercury accumulates in the tissue of fish and other aquatic animals. People are frequently exposed to mercury when they consume tainted fish. Additionally, methyl mercury persists in the environment, meaning it will endanger public health long after mercury emissions have been curbed.

Even at low levels, mercury can cause serious neurological damage to developing fetuses, infants, and children.[38] The U.S. EPA believes that lakes and rivers with more than 0.144 parts per billion of mercury present a risk to health.[39] The neurotoxic effects of low-level mercury poisoning are similar to the effects of lead toxicity in children. These impacts include delayed development and deficits in cognition, language, motor function, attention, and memory. People at highest risk include women of childbearing age, pregnant women and their fetuses, nursing mothers and infants and subsistence fishers.

Contributions of Different Electricity Sources to Air Pollution

Coal

Coal is one of the dirtiest fuels with which to produce electricity. In 1999, coal-fired power plants in Wisconsin emitted over 108,000 tons of NOx (71 percent of total NOx emissions from point sources in the state), 208,000 tons of SO2 (73 percent of total emissions), and 2615 pounds of mercury.[40]

Nuclear Power

Nuclear power plants do not emit NOx, SO2, or mercury. However, nuclear power generates radioactive waste that threatens human health. (See discussion below regarding hazardous wastes.)

Wind

Wind power plants emit no air pollution, except for what is generated during the manufacture of wind turbines.

Water Pollution

Conventional, nonrenewable fuel sources create water pollution at each step of extraction and use. Wind power has an impact only to the extent that construction of the facility increases sediment in water.

Toxics and Sedimentation

Disposal practices from mining of coal and uranium contaminate drinking water and land in the vicinity of mines. Toxins such as arsenic, mercury, chromium, and cadmium are released into unlined ponds and landfills. This adds sediment and heavy metals to streams, and can damage aquifers close to the surface.[41] In areas of extensive coal mining, the scale of the problem is enormous. For example, abandoned coal mining operations are Pennsylvania's biggest water pollution problem, and mine drainage pollutes over 1,200 miles of streams.[42] Mining for uranium is equally damaging. The Moab uranium tailings pile in Utah has contaminated local groundwater supplies and traveled down the Colorado River, a drinking water supply for 25 million people.[43]

Ocean drilling of natural gas requires the use of large off-shore platforms and disrupts the ocean environment. Construction of platforms involves installing supports for the platform, which adds sediment to the water, and increased boat traffic, which releases polluting solvents and fuels. Gas may be released into the water as a result of containment failure, run-off, pipeline accidents, and direct discharge. Drilling a single offshore well can release 180,000 gallons of toxic-laced mud and rock, and hundreds of thousands of gallons of water polluted with toxic metals.[44] Onshore drilling for natural gas creates many of these impacts also.

Offshore wind facilities also require sea-floor disruption as the towers are anchored to the ocean floor and as the turbines are connected to the on-shore transmission network by buried or covered cable on the sea floor, but over time there are no threats of spills or releases (unlike drilling), and less impact from maintenance boat traffic.[45]

Onshore, the construction of electricity generation plants triggers erosion and runoff, which increases sediment loads in surface waters.

Acid Rain

Burning fossil fuels creates large impacts on water quality. In addition to producing ground-level ozone and fine particulate matter, the combustion of fossil fuels releases nitrogen oxides and sulfur dioxide, which together create acid rain. Sulfur dioxide and nitrogen oxides in the atmosphere bond with hydrogen atoms to form sulfuric and nitric acid, respectively. These acids return to earth as rain or fog.

Acid rain and fog are extremely damaging to both forest and aquatic ecosystems. Acid rain damages the needles and foliage of trees, leaving them vulnerable to the elements, and depletes necessary nutrients from the soil in which trees grow. Acid fog has the same effects, though its effects are concentrated in the coastal and high elevation areas where fog is common.[46] Acid rain and fog, triggered by fossil fuel pollution, has caused the

decline of entire forest ecosystems throughout the East from Virginia to southeastern Canada.

Aquatic ecosystems also suffer immensely from acid rain as the acidic influx alters the natural pH of surface water. There is a direct correlation between the increase in acidity of a water body and the decline in the number of species that can live there. In Wisconsin, the Department of Natural Resources estimates that 40 percent of the state's lakes are acidic or sensitive to acid rain.[47]

Nitrogen Loading

Another extremely damaging effect of the release of nitrogen oxides into the atmosphere from fossil fuel combustion is nitrogen loading of aquatic ecosystems. Atmospheric nitrogen deposition from NOx emissions causes the overfertilization of water bodies. The resulting algal blooms starve the water of oxygen as they die and decompose, killing all life in the area. Algal blooms also block much-needed sunlight from reaching lower levels of aquatic ecosystems. Waters along the length of Wisconsin's coast suffer from algal blooms and in Barnegat Bay algal blooms have damaged eelgrass beds, which are important habitat areas.[48] Studies show that as much as 27 percent of the nitrogen that enters Maryland's Chesapeake Bay can be attributed to air pollution.[49] Undoubtedly, air pollution from burning fossil fuels contributions to nitrogen pollution in Wisconsin's waters.

Temperature Pollution

Electricity production also creates temperature pollution of water. Coal and nuclear power plants often use water as a coolant. The water is not simply recycled within the plant, but is withdrawn from a nearby source, used once, and returned to the water body. The released water is unnaturally warm and can harm fish and other aquatic life. At the Oyster Creek nuclear plant in New Jersey, releases of hot water have killed thousands of fish: an error by plant operators in September 2002 sent 106-degree water into Oyster Creek, killing over 5,000 fish.[50]

Effects of Different Electricity Sources on Water Quality

Coal

Coal mining, the construction of power plants, and burning coal all produce substantial water pollution. In 1999, Wisconsin's coal-fired power plants produced 71percent of the state's total point source emissions of NOx, a precursor of acid rain and the cause of nitrogen loading, and 78 percent of its SO2 emissions, another acid rain trigger.[51]

Natural Gas

Drilling for natural gas creates sediment and toxic pollution. Burning natural gas releases NOx and SO2 that harm water with acid rain and nitrogen loading. If the power plant uses water for cooling, the discharge will increase the temperature of the receiving water body.

Nuclear Power
Mining fuel for nuclear power plants produces mining wastes that can contaminate nearby waterways. Processing fuel creates air pollution that contributes to acid rain and nitrogen loading. Operating a nuclear power plant often involves the use of water for cooling and creates temperature pollution.

Wind
A wind power installation has little impact on water quality. Onshore, erosion and runoff from the areas around the towers may degrade surface water in the same way that a conventionally-fueled power plant would. Offshore facilities will have some impact on the sea floor during construction, but require only two maintenance trips per year thereafter. Wind-powered generation of electricity does not produce any impact on water quality.

Hazardous Waste

Coal-fired power plants produce toxic heavy metals such as mercury, which causes neurological damage. Nuclear power plants produce radioactivity that remains lethal for generations. Wind power does not produce any hazardous waste.

Hazardous Wastes from Different Electricity Sources

Coal

Burning coal produces several types of hazardous waste that must be contained and disposed of. At the bottom of the coal furnace, a coarse pebbly byproduct called bottom ash builds up; at the top of the smokestack, a fine powder known as fly ash must be filtered from exhaust gases; and at the bottom of the boiler, molten ash, or boiler slag, collects and must be removed.[52] These byproducts of burning coal contain toxic heavy metals such as arsenic, cadmium, selenium, copper, and mercury.[53]

The amount of waste produced depends on the type of coal burned. One hundred tons of Powder River Basin coal, for example, yields 4 tons of fly ash and half a ton of bottom ash.[54] Nationally, combustion of coal for electricity generation annually produces over 100 million tons of solid waste.[55] Only 30 percent of the waste is recycled; the rest is placed in landfills, old strip mines or holding ponds.[56] Whether recycled or discarded, coal byproducts can leach toxins into the environment.

Nuclear Power

The uranium fuel used in reactors and its waste products produce intense amounts of radiation. Exposure to this radiation causes serious health problems, including cancer, developmental disorders, hereditary disease, accelerated aging and immune system damage. Wisconsin is at risk from the vast quantities of radioactive material used and stored at its three aging nuclear power plants, where human error or mechanical failure could produce a dangerous release.

Preparing fuel for nuclear plants generates huge volumes of hazardous waste. The nuclear industry has produced 91 million gallons of waste from plutonium processing, 265 million tons of tailings from milling uranium ore, and a large amount of contaminated equipment.[57]

At the nuclear plants themselves, the radioactive material is perhaps even more dangerous because of the concentration of dangerous fuel and wastes in aging facilities. A single accident at a nuclear plant such as Wisconsin's Point Beach plant could release radioactive material into the environment, threatening the millions more residents of the region. Aging plants, the potential for human error, and the possibility of terrorist strikes make nuclear power clearly unsafe.

In December 2003, Point Beach nuclear plant received a red flag warning from the Nuclear Regulatory Commission, the most serious safety violation that a plant can receive. It was the second for the Point Beach Facility.[58] The violation was due to the

potential for the auxiliary feedwater system to become clogged and unable to cool the reactor in the case of an accident.

Even if plants could be guaranteed to operate without accidents or be made impenetrable to terrorist attack or sabotage, the problem of nuclear waste looms large. Extremely radioactive spent fuel—which will remain dangerous for at least 250,000 years—continues to pile up in temporary storage, with no sound method for handling the waste. Wisconsin's three nuclear power plant reactors are projected to store 1327 metric tons of spent fuel on site by 2011.[59] That amount grows each day the plants operate, making it all the more important that they shut down at the expiration of their current licenses.

Completely protecting public health and the environment from radioactive contamination is not possible. The current federal proposal for permanent storage of this waste is inadequate. Under the proposed plan, the waste would all be transported to Yucca Mountain, Nevada, a geologically unstable area above an aquifer. Shipping spent fuel rods from reactors to the repository, which has yet to begin, will be unacceptably risky, involving sending waste over highways or train routes on journeys of thousands of miles through heavily populated areas.

Once these shipments arrive at the storage site, evidence suggests that the waste will put water supplies at risk. For example, at the Hanford Nuclear Reservation in Washington, 67 of 177 underground storage tanks have leaked more than one million gallons of nuclear waste, contaminating groundwater and threatening the Columbia River.[60] After studying analyses by the U.S. Department of Energy and independent consultants, the Nevada Agency for Nuclear Projects concluded, "accidents are inevitable and widespread contamination possible."[61]

Finally, it is folly to believe that the siting of a national storage repository for nuclear waste will solve all of Wisconsin's problems with this endlessly hazardous material. If the federal Yucca Mountain nuclear waste storage site begins accepting some nuclear waste, the site will reach capacity before all of Wisconsin's waste has been moved.

Wind

Wind power creates no hazardous waste, with the exception of whatever byproducts might be generated during the manufacture of the equipment necessary to harness the natural energy source.

Habitat Destruction and Wildlife Endangerment

All the steps necessary for generating electricity—from mining and extraction through transmission and combustion—can harm wildlife and birds by destroying or altering habitat. The site of electricity generation—whether conventional power plants or wind farms—consumes habitat. For each method of production, the total habitat area affected is greater than the actual footprint because human activity disturbs birds and wildlife in surrounding areas.[62] Traditionally fueled power plants consume more habitat and natural resources than clean, renewable sources because they require mining, extraction, and transport of fuel in addition to the site of the power plant. Each step along the way—from the drilling or mining of coal, gas, or uranium, to the road building needed to transport that fuel (often from remote, wild areas), to the construction of the energy facility—impacts wildlife and alters land.

Power plants themselves create more dangers for wildlife. For example, an average of 540 birds died each year over a five-year period at two smokestacks in Florida.[63] Birds of 50 species were killed. Presumably large numbers of birds die each year at the thousands of power facilities across the United States.

Impacts on Wildlife from Water and Air Pollution

Pollution released from coal and natural gas plants harms wildlife. Acid rain, caused by nitrogen oxides and sulfur oxides from burning fossil fuels, has damaged thousands of acres of forest, injuring resident wildlife. The wood thrush, for example, is less likely to breed in areas where calcium levels in the soil have been depleted by acid rain.[64] Thus acid rain has reduced the amount of habitat available to the wood thrush. Water pollution, whether from acid rain, oil spills, or unnatural temperatures, kills fish and other aquatic creatures. Global warming, spurred by emissions of greenhouse gases from fossil fuel plants, will harm wildlife around the world.

Impacts on Wildlife from Electricity Distribution

The final step in electricity production, delivering it to consumers, also affects wildlife. Power lines, necessary for carrying electricity from often remote generation sites to areas of demand for electricity, electrocute thousands of birds annually. There are over 500,000 miles of bulk transmission lines in the United States; this figure does not include local distribution lines.[65] With this vast network, power lines may kill as many as 174 million birds annually, though this figure is highly speculative. Estimates of bird fatalities per mile of transmission line range from 200 to 350 per year.[66] These figures of deaths per mile are important because new electricity-generating facilities are often located miles from where the electricity will be consumed and thus require extensive transmission lines. Whether the power source is a coal-fired power plant or a large windfarm, every additional mile of transmission line will have a significant avian impact.

Effect of Different Electricity Sources on Wildlife and Habitat

Coal

Coal has specific and quantifiable impacts on habitat and wildlife. Mining has destroyed thousands of acres of habitat and continues to consume more. Electricity produced at coal power plants damages habitat and wildlife over a wide area.

Strip-mining, removing all topsoil to reach coal deposits, is the method by which 87 percent of coal from the western United States is produced.[67] In the east, coal mining is no less destructive. Mining has consumed over 250,000 acres of Pennsylvania countryside.[68] Mountaintop removal mining has leveled 15 to 25 percent of the mountains in southern West Virginia, burying 1,000 miles of streams in waste and eliminating 300,000 acres of hardwood forest.[69]

This habitat destruction harms wildlife. For example, a single mountaintop mining operation at Braden Mountain, Tennessee, is projected to disturb over 100 breeding pairs of Cerulean warblers, a species that has declined by 70 percent in the past 40 years and is listed as a threatened species in two states.[70] Habitat loss is a major contributor to the bird's decline.

Coal combustion damages both aquatic and terrestrial habitat with acid rain and toxic chemicals. However, because coal burning emits so much greenhouse gas pollution, the biggest threat to wildlife from coal-fired power plants is global warming.

Natural Gas

Natural gas wreaks similar devastation on habitats and wildlife. Extraction of natural gas, onshore or offshore, requires destroying habitat and disturbing wildlife.

Offshore gas drilling facilities, though they cause relatively little direct habitat loss, still can harm wildlife. Construction of offshore gas platforms disturbs marine wildlife. Seismic surveys and drilling activity affect gray whales, sperm whales, beaked whales, and bowheads. In extreme cases, fish and seals have died of shock when hammering was started too suddenly and intensely.[71]

Offshore drilling platforms also create a problem for migrating birds. Brightly lit platforms attract and confuse migrants. Birds become disoriented, especially by nighttime lighting, and waste energy circling the platform.[72] Some become too exhausted to continue their migration and die when they land in the ocean.

Natural gas pumping platforms onshore are no less of a problem for birds. The tall towers create a collision danger and lights on the towers draw birds in. This combination proves fatal for thousands of birds. For example, over the course of two days, 1,393 songbirds of 24 species were killed after colliding with a flare stack in Alberta.[73]

Natural gas power plants present a collision hazard for birds. Nitrogen oxide and sulfur dioxide emissions from natural gas plants pollute aquatic ecosystems with nitrogen

loading and a wide area of land with acid rain. Greenhouse gases released by natural gas combustion contribute to global warming.

Nuclear Power
Uranium mining, like coal mining, destroys habitat and thus harms wildlife. More significantly, nuclear power has terrifying potential to kill for centuries to come.

Nuclear power plants directly kill fish and wildlife. Vast numbers of fish die at nuclear power plants that use water as a coolant. The fish get caught in the intake screens or are sucked into the plant. The Salem Nuclear Generating Station on the Delaware River, for example, uses up to 3 billion gallons of water daily and annually kills 3 billion fish, including 59 million blueback herring, 77 million weakfish, 134 million Atlantic croaker, 412 million white perch, 448 million striped bass, and 2 billion Bay anchovy.[74] Artificially high temperatures from water returned to the river may kill more aquatic animals.

As discussed earlier, radioactive waste produced by nuclear facilities remains a threat to all life for hundreds of thousands of years.

Wind
Wind power has more modest impacts on habitat and wildlife. It does not require the mining or transportation of fuel. It does not produce air pollution or contribute to global warming.

Wind installations consume some land for each turbine and may alter wildlife behavior in the surrounding area. Studies of bird behavior around wind power installations, for example, show that some species change their feeding, breeding, and nesting habits outside the immediate area of the wind towers.[75]

Though turbines are often spread over a large area, the actual amount of land consumed may be small. At the Stateline wind project in Oregon and Washington, the initial proposal for 127 turbines spread over 9,600 acres estimated that they would occupy or permanently disturb only 60 acres of land, or approximately half an acre per turbine.[76] When the land in question is already used for intensive agriculture, then the wildlife impact and habitat loss is minor. In more remote areas, the disruption from a wind farm will be more significant.

Wind turbines create a collision danger for birds and bats. Studies of wind turbine projects in the United States indicate that bird mortality varies from less than one bird collision per turbine each year up to 7.5 birds per turbine each year. The National Wind Coordinating Committee estimates that 20,000 birds were killed at the 6,400 MW of U.S. wind capacity generation installed at the end of 2003, with more than half of those collisions occurring in California. The average number of bird collisions per turbine was estimated at 2.3 birds per turbine per year. This equates to three bird collisions per megawatt per year outside of California.[77]

Bat mortality at wind farms ranges from 0.7 bats per turbine per year at the 38 turbines in Vansycle, OR to a high of 48 in 2003 at the Mountaineer Wind Energy Project in West Virginia. The high mortality rates at the 44 turbines at the West Virginia Mountaineer wind project have instigated a collaboration between biologists, the wind industry, and federal officials to further study the reasons for higher mortality at some locations.

As more wind farms are erected in the United States, new research continues to discover ways to avoid unnecessary wildlife disruption from wind farms. Overall, wind power projects are responsible for only one or two of every 10,000 bird collision-deaths in the country annually.[78] Even as more turbines are installed, properly sited wind power plants will cause only a small fraction of overall avian collision-deaths each year.

Table 2. Sources of Avian Collision Deaths[79]

	Low Estimate	**High Estimate**	**Volume of Related Facilities**
Buildings and windows	98 million	980 million	100 million buildings
Vehicles	60 million	80 million	4 million miles of road
Communication towers	4 million	50 million	80,000 towers
Power lines	tens of thousands	174 million	500,000 major transmission lines
Wind generation facilities	10,000	40,000	15,000 turbines (est. as of 2001)

Wind farms may interfere with birds' migration by creating an obstacle. Seeing structures, such as buildings or a wind farm, some birds may make a detour around the development, thus lengthening their migration.[80] Multiple, large wind farms cumulatively may have an impact that creates a problem as birds have to circumnavigate a larger obstacle. The extent to which wind farms change behavior depends on the species of bird.[81]

Aesthetic Impacts

Any electricity production facility—whether a natural gas plant or a wind farm—has visual and noise impacts. Construction requires clearing land, building roads, and installing transmission lines. The facility itself will likely involve multiple large buildings. It will also produce some noise, both short-term construction-related and long-term operational noise.

Coal and Natural Gas

Mining for coal and uranium is both ugly and noisy. There is nothing subtle about strip mining and the loss of mountaintops to mining changes entire vistas. Oil wells have been located in some of the world's most scenic locations. Global warming caused by burning fossil fuels will alter what plants will grow and when they undergo seasonal changes, and affect what birds can be sighted in Wisconsin.

As for noise, communities near mining sites must deal with blasting and increased heavy-vehicle traffic.

Nuclear Power

Mining fuel for nuclear power plants causes extensive visual damage. Nuclear power plants themselves are large, concrete structures.

Wind

Wind farms are highly visible. Each modern wind turbine typically is 200 to 260 feet high, with blade rotors of 150 to 225 feet in diameter.[82] Wind power plants consist of clusters or lines of turbines spread across hilltops, ridgelines, or open stretches of water. Viewed from a distance of half a mile or less, details of turbines are visible. Turbines seven miles away are generally insignificant. Distant wind projects may become more visible at night because the Federal Aviation Administration requires that towers over 200 feet tall be lit.[83]

During operation, wind power plants produce steady, low-volume noise, caused by wind trailing off rotor blades and by the machinery driven by the rotors. (See table 3 for comparison of noise impacts.) The wind itself may mask any noise produced by the turbine.

Table 3. Relative Volume of Wind Turbine Versus Other Common Sources of Noise[84]

Source	Distance (feet)	Sound Level (decibels)
Jet engine	200	120
Freight train	100	70
Vacuum cleaner	10	70
Freeway	100	70
Large transformer	200	55
Wind in trees	40	55
Light traffic	100	50
300 kW wind turbine	400	45
Soft whisper	5	30

Opportunities to Mitigate the Impacts of Wind Power

Two common concerns related to wind development are potential impacts on birds and other wildlife, and visual and noise effects of turbines, especially on nearby property owners. This section will review options for mitigating these impacts.[85]

Avian Concerns

Wind turbines present a risk to birds and bats. The towers create an obstacle in unnatural places, where no hazard existed before. Furthermore, a few early wind projects such as the one constructed at Altamont Pass, California, killed alarming numbers of large birds. For these reasons, there is concern about how wind installations impact birds.

Since the country's first modern wind turbines were built two decades ago, much research has been conducted to study the ways to reduce impacts on birds. As discussed in the first section of this report, wind turbines in the United States on average cause 2.3 bird deaths each year, a low number relative to deaths caused by other sources. However, some sites will have larger impacts on bird populations than others, and so the location of new projects should be carefully considered.

Areas that are heavily used near the ground by birds, particularly threatened species, likely are inappropriate locations for wind projects.[86] Locating wind towers in areas of heavy use may be acceptable if the use occurs at higher altitudes, such as by migrating birds. Migrating birds typically fly at altitudes higher than the tops of modern wind turbines.[87] Songbirds often migrate at 500 to 1,000 feet; most other birds migrate at an altitude of 1,500 to 2,500 feet.[88] Modern wind towers are only 200 to 260 feet high, well below migrating birds. With a blade extended straight up, turbines can reach nearly 400 feet, but this is still below the level of migrants.

Bird use at lower altitudes may be compatible with building a wind farm. Some species of resident birds can co-exist with a wind farm because they may become accustomed to wind turbines and alter their flight patterns to avoid the towers and rotors.[89]

The first step to protecting birds is the site study, a review conducted before any wind turbines are erected to reveal a project's potential impact on birds. Understanding how the project might present a risk to birds and what species of birds are vulnerable can suggest what mitigation measures might be appropriate. The site study should take advantage of both visual surveys and radar technology.

The impact of wind turbines on birds is specific to whether the plant is built on-shore or off-shore, to the height range of the turbines, to how quickly the rotors turn, and to what birds inhabit the area. Different species will respond differently to the same plant and may vary their behavior according to the season. The site study can determine what species use the area.

Mitigation options are widely varied. Wind project impacts on birds potentially can be reduced through design and siting decisions. For example, turbines with tubular rather than lattice-work bases may be safer. Lattice-work towers offer many perches, making it easy for birds to congregate at the towers. With more birds in the area, the odds rise that a bird will collide with a turbine. Tubular towers offer no resting points.[90]

Wind turbines, communication towers, and meteorological towers should also use no guy wires, which can create an additional collision for birds.

Larger turbines may cause fewer bird deaths than smaller, older turbines, but no studies have yet conclusively demonstrated this.[91] Rotors on older turbines spin at a rate of 60 to 80 revolutions per minute, too fast for birds to see the blades.[92] Newer, larger turbines have relatively slow-turning rotors that revolve 11 to 20 times per minute. At this lower speed, birds can see more of the blade in motion and respond to the danger. Additionally, preliminary research suggests that painting rotor blades in different patterns might help birds better see and avoid moving blades.[93]

The lighting of turbines is also important. The wrong lighting may draw birds toward the structures at night. Birds seem most drawn to solid or pulsing red lights. The number of lit turbines should be minimized whenever possible. White strobe lights that flash at the Federal Aviation Administration minimum of 20 flashes per minute appear to have the least impact.[94]

Construction can be timed to avoid periods of peak use by birds, such as during the spring migration season.[95]

The extent to which wind developments create a barrier to free movement by birds can be reduced by leaving space between clusters of turbines so that any detour birds take will not be lengthy.[96] Depending on the area, turbines might need to be clustered with large spaces between groupings to allow birds easy passage from feeding, roosting, and breeding areas.[97]

Even with all these adjustments, some locations may be inappropriate for wind energy development. Site-specific reviews before the project is approved and dialogue between the permitting agency and the wind developer will allow a determination of what measures are necessary to protect birds.

Visual and Noise Concerns

A secondary concern that arises regarding wind farms is their visual and noise impacts. Modern wind towers are tall and thus are visible from a substantial distance. Residents simply may not want turbines added to the view from the living room window. In other cases, questions may arise about the suitability of wind turbines in natural and scenic settings. Regarding noise, neighbors of proposed wind developments often worry that they will be disturbed by the sound of wind blowing against the rotors and mechanical noises as the rotors drive a generator.

Proper design and siting can minimize the extent to which these concerns become real. Visually, tubular towers have a different impact than do lattice-work bases: up close, tubular bases may be more attractive, but lattice-work ones may be less visible from a distance.

How wind turbines are arranged relative to the landscape also matters: a single line of turbines following a ridge may be more appealing than turbines scattered across a hill. A detailed drawing or digitally-altered photo can provide a preview of what the visual impacts will be and facilitate selection of the arrangement with the smallest impact.

The visual damage caused by supporting infrastructure can be reduced by careful placement of roads, the use of erosion-control measures, and by maintaining and protecting as much vegetation as possible. Transmission lines that connect the towers to each other and that connect the project to the grid will have a smaller visual effect if the developer buries the cables.

Requiring a buffer zone between a wind power installation and residences, schools, hospitals, and other sensitive locations can mitigate noise impacts of wind projects. Palm Springs, California, for example, requires a 1,200 foot buffer zone between any wind turbine and non-commercial development.[98]

Through the review process, concerns and potential problems with a wind development can be identified and measured. The right permitting procedure will offer opportunities for modifying the project to address these issues.

The Next Steps for Wisconsin

The harm from coal, natural gas, and nuclear-fired power plants is real and immediate. Wisconsin cannot afford a lengthy delay in reducing its dependence on these dirty electricity sources.

Wind farms are becoming an increasingly common sight in Wisconsin as nearly 450 MW of wind projects are currently under development in Wisconsin. This is an excellent beginning, but local wind projects are still too few in number relative to the amount of new fossil fuel energy that is being proposed in Wisconsin. Currently, there are over 7000 MW of fossil fuel plants proposed for Wisconsin.

Wisconsin already has the necessary regulatory framework for promoting wind energy above polluting sources of energy. Under the Wisconsin Energy Priorities Law, Wisconsin is supposed to meet new energy demands in the following order:

1. Energy conservation and efficiency
2. Noncombustible renewable energy
3. Combustible renewable energy
4. Nonrenewable combustible energy sources
    A. Natural gas
    B. Oil or coal with a sulfur content of less than 1%
    C. All other carbon-based fuels

Wisconsin also has a good framework for ensuring that the concerns associated with large scale wind projects are addressed. Wisconsin law and Administrative Code as it stands recognizes the overall minimal environmental footprint of windturbines: it exempts them from local zoning restrictions and only farms over 100 MW are required to apply for a Certificate of Public Convenience and Necessity (CPCN) from the Public Service Commission (PSC). A CPCN ensures an environmental review process but projects over 10MW are considered Type II projects which require an Environmental Assessment rather than a full-blown EIS (although the Commission can require a full EIS at its discretion.)

What is needed in Wisconsin is an insistence that the PSC actually follow our energy priorities law. Secondly, we need to develop the understanding of local decision-makers about the environmental and economic potential for renewable energy projects. Finally, developers should be working to incorporate the input of local property owners and residents as they develop wind projects.

The state could also pursue advance site selection to identify which general locations in the state are acceptable for wind projects. The best sites experience strong winds, are not heavily used by birds, and already have experienced some environmental degradation from other infrastructure. This would reduce the potential for disagreement over particularly sensitive areas and would give wind developers confidence that the locations they propose have a reasonable chance of receiving approval.

The impacts of our electricity choices are clear. Wind power is a critical piece of a clean and safe energy future for Wisconsin and for our country that our larger neighboring states have already begun to tap. Wisconsin cannot afford to forego opportunities within our own borders for the development of this nonpolluting source of energy.

Notes

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