The Environmental Case for Wind Power in New Jersey

Elizabeth Ridlington
Emily Rusch

NJPIRG Law & Policy Center

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Executive Summary

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

The state's electricity demand is expected to grow by at least 14 percent over 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 to replace power from dirty or unsafe plants as they are retired.

Generating power by using fossil fuels or nuclear power imposes unbearable costs on our environment, our health, and our economy. Instead of increasing our dependence on dangerous, polluting sources such as coal, natural gas and nuclear power plants, the state must tap into clean, sustainable energy resources such as wind power.

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 New Jersey will be significantly altered within the next century.

- Within the next 50 years, the ocean will rise one to four feet along the Atlantic coast. A 2.3-foot rise in ocean levels would threaten up to 433 square miles of coastal land in New Jersey with increased flooding. The impacts of global warming are likely to be most noticeable along the shore, through lost shoreline, saltwater intrusion in fresh water supplies, an increase in extreme weather events like storms and flooding, and resulting damage to coastal properties.
- 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 31 species of birds to change their ranges to exclude New Jersey.
- Warming is already occurring: temperatures in the past century have risen by an average of one degree.

- In 2001, New Jersey's coal, oil, and gas-fired power plants released an estimated 19 million metric tons of carbon dioxide—emissions equivalent to those from half of the cars on New Jersey's roads.

Air and Water Pollution

Fossil fuels burned to produce electricity also contribute to New Jersey'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 79 times in New Jersey, and the U.S. Environmental Protection Agency has designated all of New Jersey 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 much of New Jersey, 10 to 20 percent of surface waters are acidic due to acid rain. Over 90 percent of the streams in New Jersey's Pine Barrens are chronically acidic (the highest rate in the nation), killing resident trout.
- Mercury from coal-fired power plants has contaminated the state's lakes and streams, putting children at risk of nuerological damage and prompting a statewide advisory on fish consumption.

Nuclear Hazards

Nuclear power plants are another environmental crisis in the making. New Jersey'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.
- New Jersey's four nuclear power plants have generated and currently store 1,688 metric tons of spent fuel. These facilities have no safe storage options for their waste and aging equipment at the plants increases the odds of an accident.
- An accident involving radioactive material—whether due to mishandling, equipment fatigue or a terrorist act—could endanger thousands of people, including the growing population of Ocean and Salem counties and the greater Philadelphia metro area.
- Evacuation plans are woefully inadequate.

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.
- Nuclear power plants disrupt aquatic habitat. New Jersey's Salem Nuclear Generating Station draws water from

the Delaware River for cooling purposes, killing 3 billion fish annually.

- 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 New Jersey's growing electricity demand.

Any specific wind project, whether onshore or offshore, will have impacts. A permitting process should be put in place to examine impacts for ecological significance. An appropriate wind project permitting process will allow decision makers and the public to weigh the local impacts of a wind development against the broader effects of alternative power sources.

The review process for any wind facility in New Jersey should include the following:

- Opportunities for participation from all involved constituencies.
- A comparison to potential impacts of traditional electricity production options, to ensure that the consequences of coal, natural gas, or nuclear power are considered.
- Clear decision criteria established in advance: what factors will be considered, what requirements a facility must meet regarding environmental and public health impacts, and how those impacts will be evaluated (site studies, computer modeling, or other methods).
- Independent review of the developer's plans by technical experts who can effectively assess impacts of the development.
- A timeline for the permitting process including interim steps and decision points, so that developers can plan their project and the public can be made aware of opportunities for comment.
- Post-construction monitoring of the turbines.

Because few wind power facilities have been constructed in coastal areas of the East Coast of the United States and none yet offshore, there is some uncertainty about the potential impacts of such an installation. No permitting process will be able to provide this data. Rather, the information will come from the first few projects as they are built and begin operating. In light of the relative environmental consequences of the state's current and future energy supply options, New Jersey should encourage one or more wind facilities as test cases, and then apply the data gathered from those developments to the review of future proposals.

Introduction

People are drawn to New Jersey's coast by its natural beauty and resources. Miles of open beach offer space for a quiet stroll or a lively family outing. From homes along the edge of the beach, residents have an unobstructed view of open ocean. 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.

The Jersey Shore also has substantial wind resources. Wind turbines erected in areas that receive strong winds, both along the coast and offshore, have the potential to generate non-polluting electricity to help meet New Jersey'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. But windmills might be the salvation of the Jersey Shore.

The number one threat to the shore 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 migration patterns of sea life, as well as to higher sea levels. Within a century the ocean will inundate low-lying areas, turning wetlands into ocean and destroying habitat for thousands of birds and other wildlife. Monthly high tides will threaten more houses and roads. Winter storms will strip more sand from beaches and wash away more structures. No one can fully predict the results of global warming on the Shore 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 or stop the rise in sea levels, 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 New Jersey, 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.

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

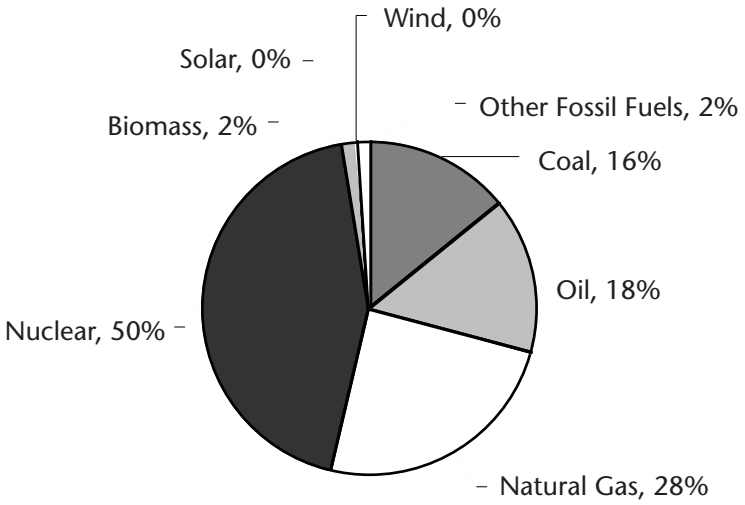
New Jersey's Electricity Demand and Production

New Jersey consumes 70 million megawatt-hours (MWh) of electricity each year to heat homes, light offices, and run factories.[1] Of the electricity produced in New Jersey, 50 percent comes from nuclear power, 28 percent from natural gas, and 16.5 percent from coal.[2] Oil, solid waste, dirty sources of biomass (such as sewage sludge) and other polluting energy sources contribute the rest of New Jersey's electricity. Less than 1 percent comes from clean, renewable sources such as solar, biomass from clean sources, and wind power.

By the year 2012, as the state's population and economy expand, demand for electricity is expected to grow by 10 million MWh to more than 80 million MWh total.[3]

Some of this new demand can be met cheaply and cleanly through conservation—using less energy—and efficiency—reducing the amount of energy necessary

Figure 1. Source of Electricity Generated in New Jersey



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).

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. New Jersey 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, New Jersey 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 supply a percentage of our energy from clean, renewable sources. In 2003, then-Governor McGreevey announced a goal that by 2020, New Jersey should receive 20 percent of its energy from clean, renewable sources. To reach this goal, in 2004, the New Jersey Board of Public Utilities voted to increase the amount of clean, renewable energy we use in New Jersey in the next several years, requiring 4 percent of our electricity to come from clean sources by 2008. Now, the state must decide which clean power facilities to build where. The state also set targets for rapid growth in the development of solar energy. However, solar energy alone will not meet all of our energy needs in the near future.

One important renewable energy source for New Jersey is wind power, most accessible in the northwest corner of the state, along the coast and offshore, as seen in

Figure 2. Map of New Jersey's High Wind Energy Potential Regions

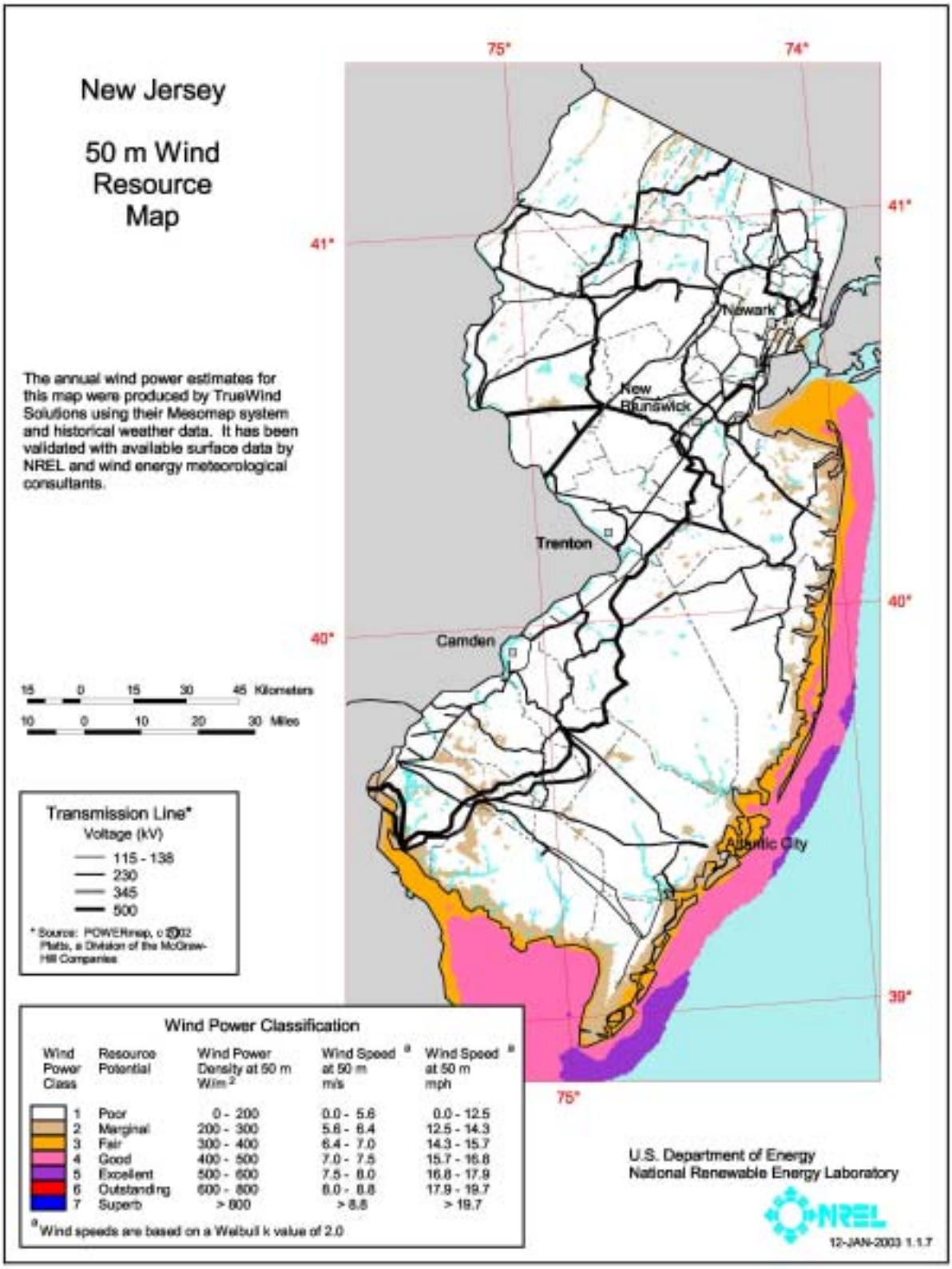


figure 2. According to the U.S. Department of Energy, assuming that wind turbines are not erected in urban areas or on environmentally sensitive land, New Jersey could generate over 2 million MWh of electricity from wind power.[4]

Offshore wind resources are more abundant, but have not yet been fully quantified. Offshore wind turbines in Europe have been built in water depths of up to 65 feet, and within the next 5 years, technology improvements will allow wind turbines to be installed in water up to 100 feet deep. In New Jersey, depths of 100 feet occur as far as 12 miles offshore.[5] Wind developers prefer locations that can be easily connected to main transmission lines and in close proximity to centers of energy demand so that transmission losses are smaller.[6]

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.[7]

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.[8] 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.[9] 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.[10] Within New Jersey, temperatures have already begun to rise. The average temperature measured in New Brunswick from 1889 to 1918 was 50.4°F; the average temperature in the same location from 1966 to 1995 was 52.2°F, an increase of nearly two degrees.[11]

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.[12]

Human Health Risks

Higher temperatures will harm New Jersey residents' health. A study conducted in Newark suggests that summertime heat-related deaths may quintuple if temperatures rise just 2° to 3°F.[13] The concentration of ground-level ozone, which worsens asthma and reduces lung function, will increase as temperatures rise.[14] Ozone levels already exceed public health standards and present a severe public health threat in New Jersey. Further increases will sicken even more New Jersey residents.

Rising Ocean Levels

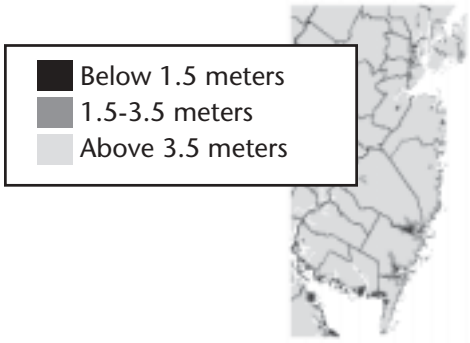
One sure impact of global warming in New Jersey will come from rising ocean levels. Sea levels along the New Jersey shore have

been rising at a rate of one inch every six years.[15] Within the next 50 years, the ocean will rise one to four feet along the Atlantic coast.[16] At Atlantic City, sea levels will almost certainly rise by 10 inches and perhaps by as much as 20 inches by 2050.[17]

Nationwide, 10,000 square miles of coastal lands will be flooded.[18] One study, which has been cited by the federal Environmental Protection Agency, projects that a 2.3-foot increase in sea level will increase flooding for 433 square miles of New Jersey's coastal areas.[19] Especially hard-hit will be areas along the Delaware Bay, and the lower portions of the Great Egg Harbor River and the Mullica River. (See Figure 3.)

Rising sea levels will erode beaches and inundate existing wetlands.[22] Most affected will be coastal marshes, swamps and wetlands. Higher water levels will create new wetlands farther inland, but existing development along the shoreline will limit this inward migration, resulting in a decrease in the total amount of wetlands along New Jersey's shore.[23] This loss will reduce the amount of area available to birds and other wildlife for breeding, wintering and use as migratory stopovers. Already, populations of the least tern, a state-listed endangered species that nests in open sandy areas, are declining due in part to the loss of breeding habitat as coastal flooding consumes more beaches.[24]

Figure 3. Areas of New Jersey's Coast Vulnerable to Flooding[20]



The coastal areas marked in black will be flooded several times per month by high tides in the next century.[21]

Saltwater Intrusion

As oceans move inland, seawater may contaminate previously non-saline groundwater and surface water supplies. For example, oyster populations in the Delaware Bay appear to be declining as a result of the increased salinity of the bay.[25] Aquifers will also be subject to increasing salinity, potentially threatening water supplies such as the Potomac-Raritan-Magothy aquifer, which serves Camden and central New Jersey.[26] During periods of drought, the salt levels in the aquifer could regularly exceed the concentration levels established by federal drinking water standards.[27] Cape May already suffers from saltwater intrusion into the aquifers that provide the city's drinking water and had to construct a $5 million desalination plant in 1998 to ensure an adequate water supply. Global warming may force more communities to purchase such expensive infrastructure.[28]

Wildlife Disruption

Global warming will cause significant disruption of ecosystems and thus of wildlife habitats.[29] 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.[30] 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.[31] 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.[32] 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.[33]

In New Jersey, one of the ecosystems most likely to be hurt is the forested Pine Barrens, which provides valuable wildlife habitat for rare species such as the pine barrens treefrog, a state-listed endangered species.[34] When animals inhabiting the Pine Barrens find their habitat rendered unsuitable by global warming, they will likely not be able to migrate to other areas because there are few natural migration corridors leading out of the area.[35]

Over 30 species of birds may disappear from New Jersey as they follow their shifting habitat. Though their present ranges include New Jersey, the birds will be forced to leave as global warming makes ecosystems within the state unable to support those species.[36] (See Table 1.)

Seabirds are also very vulnerable to global warming. Small changes in ocean temperature may influence seabird reproduction rates.[38] For example, the productivity of red-legged and black-legged kittiwakes responds measurably when ocean temperatures change by as little as one degree Celsius.[39] Short-term changes in the Pacific Ocean due to cyclical cooling and warming of the ocean have altered food

Table 1. Birds Species That May Disappear from New Jersey Due to Global Warming

Alder Flycatcher	Yellow-rumped Warbler
Willow Flycatcher	Black-throated Green Warbler
Least Flycatcher	Blackburnian Warbler
Tree Swallow	American Redstart
Bank Swallow	Northern Waterthrush
Cliff Swallow	Canada Warbler
Black-capped Chickadee	Rose-breasted Grosbeak
Red-breasted Nuthatch	Vesper Sparrow
Winter Wren	Savannah Sparrow
Blue-headed Vireo	Swamp Sparrow
Blue-winged Warbler	White-throated Sparrow
Golden-winged Warbler	Dark-eyed Junco
Nashiville Warbler	Bobolink
Chestnut-sided Warbler	Purple Finch
Magnolia Warbler	Pine Siskin
Black-throated Warbler	

availability and thus bird abundance.[40] 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.[41]

Contributions of Different Electricity Sources to Global Warming

Coal

Coal-fired power plants are major producers of greenhouse gases, responsible for 9 percent of the global warming emissions in New Jersey.[42] The state's coal-fired power plants released an average of 2,503 pounds of carbon dioxide (CO2) per MWh produced in 1999.[43] In 2001, coal-fired power plants released an estimated 10.7 million metric tons of carbon dioxide equivalent (MMTCO2E), equal to the carbon emissions from over 1.5 million cars, or 33 percent of the vehicles on the road in New Jersey.[44] While the emissions from coal-fired power plants in New Jersey are significant, those numbers do not account for the energy New Jersey receives from coal-fired power plants in neighboring states like Pennsylvania. Nationally, coal-fired power plants produce 32 percent of the country's carbon dioxide pollution.[45]

Table 2. Amount of Carbon Dioxide That Directly Results from Generating 100 MWh of Power, by Fuel Source[47]

	CO2 (metric tons)
Wind	0
Natural Gas	45.7
Coal	107.1

Natural Gas

Natural gas plants, though cleaner and more efficient than coal plants, still produce vast quantities of greenhouse gases. Natural gas plants in New Jersey released an average of 1,007 pounds of CO2 per MWh of electricity generated in 1999—for an annual total of approximately 7 million metric tons—the equivalent of the emissions from nearly 1 million cars, 20 percent of New Jersey's vehicle fleet.[46]

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 New Jersey residents.

Wind

Electricity produced by wind energy does not contribute 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. In fact, air pollution is the third highest preventable public health threat in New Jersey, behind only obesity and smoking.[48] 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 79 times in New Jersey, an unusually low number due to mild weather.[49] Ozone levels across the state are high enough to damage human health, so the U.S. Environmental Protection Agency has designated the entire state of New Jersey as violating ground-level ozone standards.[50]

Chemically identical to the atmospheric 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.[51]

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.[52]

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.[53] Fossil-fuel power plants emit 70 percent of national sulfur dioxide emissions and 28 percent of all particulate matter.[54] In New Jersey, dirty power plants are responsible for over half of particulate matter releases.[55]

Mercury

Power plants also release mercury and other heavy metal air toxins. Coal-fired power plants in New Jersey emitted nearly 200 pounds of mercury in 1999.[56] Less than one gram of mercury deposited into a 20-acre lake is enough to make the fish there unsafe to eat.[57] As a result, New Jersey 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.[58] The U.S. EPA believes that lakes and rivers with more than 0.144 parts per billion of mercury present a risk to health.[59] 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.

Karen Smith/Ontario Clean Air Alliance

Coal-fired power plants contribute heavily to New Jersey's smog problem.

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 New Jersey emitted 24,000 tons of NOx (6 percent of total NOx emissions in the state), 46,000 tons of SO2 (24 percent of total emissions), and 180 pounds of mercury.[60]

Natural Gas

Even less-polluting fossil fuels, like natural gas, produce substantial hazardous air emissions. New Jersey's natural gas-fired plants released 8,600 tons of NOx and 291 tons of SO2 in 1999.[61]

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.

Table 3. Emissions from New Jersey Power Plants in 1999[62]

Annual NOx emissions (tons)	Annual SO2 emissions (tons)	Annual mercury emissions (tons)
39,806	52,119	581

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.[63] 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.[64] 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.[65]

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

V. Stockman/www.ohvec.org

Marfork Coal's Brushy Fork coal slurry impoundment, which, at its final stage, will hold 8 billions of gallon of coal waste sludge. The impoundment partially lies over old underground mines and is directly upstream from the town of Whitesville, WV.

of toxic-laced mud and rock, and hundreds of thousands of gallons of water polluted with toxic metals.[66] Onshore drilling for natural gas creates many of these impacts also.

Offshore wind facilities also require seafloor 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.[67]

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.[68] 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 much of New Jersey, 10 to 20 percent of surface waters are acidic due to acid rain. Over 90 percent of the streams in New Jersey's Pine Barrens are chronically acidic, the highest rate in the nation.[69] This acidity has caused a decline in trout populations.

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 over-fertilization 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 New Jersey's coast suffer from algal blooms and in Barnegat Bay algal blooms have damaged eelgrass beds, which are important habitat areas.[70] Studies show that as much as 27 percent of the nitrogen that enters Maryland's Chesapeake Bay can be attributed to air pollution.[71] Undoubtedly, air pollution from burning fossil fuels contributions to nitrogen pollution in New Jersey'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. The Salem Nuclear Generating Station draws as much as 3,000 million gallons of water each day from the Delaware River for cooling purposes. When the water is returned to the river, it may be as hot as 115 degrees Fahrenheit, far warmer than the natural temperature to which aquatic animals are accustomed.[72] At the Oyster

Creek nuclear plant, 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.[73]

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, New Jersey's coal-fired power plants produced six percent of the state's total emissions of NOx, a precursor of acid rain and the cause of nitrogen loading, and 24 percent of its SO2 emissions, another acid rain trigger.[74]

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 should have little to no impact during operations.

An accident at the Oyster Creek Nuclear Generating Station could expose thousands of people to radioactive material.

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.[75] These byproducts of burning coal contain toxic heavy metals such as arsenic, cadmium, selenium, copper, and mercury.[76]

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.[77] Nationally, combustion of coal for electricity generation annually produces over 100 million tons of solid waste.[78] Only 30 percent of the waste is recycled; the rest is placed in landfills, old strip mines or holding ponds.[79] 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 radiation. Exposure to this radiation causes serious health problems, including cancer, developmental disorders, hereditary disease, accelerated aging and immune system damage. New Jersey is at risk from the vast quantities of radioactive material used and stored at its four 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.[80]

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 New Jersey's Oyster Creek plant could release radioactive material into the environment, threatening the 100,000 people living within 10 miles of the plant and millions more in the region. Aging plants, the potential for human error, and the possibility of terrorist strikes make nuclear power clearly unsafe.

The Oyster Creek Nuclear Generating Station in Lacey Township provides an example of the danger posed to New Jersey by nuclear power. Oyster Creek, the oldest operating plant in the nation, stores 35 years' worth of radioactive material on site. The pool containing the spent fuel is located on the top floor of a five-story building and is contained by several exterior walls of the plant. According to a Nuclear Regulatory Commission report, reactors like Oyster Creek "do not appear to have any significant structures that might reduce the likelihood of aircraft penetration."[81] If the water covering the fuel were drained, an uncontrolled radioactive fire would begin to release high levels of radiation. According

to one estimate, a severe fire in a spent fuel pool could render about 188 square miles uninhabitable—in New Jersey, home to millions of people—and cause as many as 28,000 cancer fatalities.[82]

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. New Jersey's four nuclear power plants have generated and currently store 1,688 metric tons of spent fuel.[83] 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.[84] 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."[85]

Finally, it is folly to believe that the siting of a national storage repository for nuclear waste will solve all of New Jersey'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 New Jersey'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.

Sandy Ridlington

One mile of bulk transmission lines may kill as many as 350 birds per year.

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.[86] 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.[87] Birds of 50 species were killed. Presumably large numbers of birds die each year at the thousands of power facilities across the United States.

In an already crowded state like New Jersey, any loss of habitat to the development of a new electric generation facility is cause for concern. For polluting sources of energy, the wildlife impacts are multiplied by increased pollution.

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.[88] 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.[89] 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.[90] 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 wind farm, 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.

V. Stockman/www.ohvec.org

Mountaintop removal coal mining operations, such as this one in West Virginia, destroy thousands of acres of habitat.

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.[91] In the east, coal mining is no less destructive. Mining has consumed over 250,000 acres of Pennsylvania countryside.[92] 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.[93]

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.[94] 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.

Sandy Ridlington

Natural gas pipelines, though narrow, are thousands of miles long and thus destroy substantial amounts of habitat.

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.[95]

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.[96] 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.[97]

Transporting natural gas has clear habitat impacts because the transporting facilities are constructed for that specific purpose (in contrast, coal is shipped using existing roads and railways). Liquefied natural gas (LNG) must be shipped by tanker, and large shipping and receiving facilities must be constructed on coastal land. BP has proposed constructing an LNG terminal on a 175-acre site in Logan Township, on the banks of the Delaware River. The facility would have three large storage tanks and a pier for docking tanker ships, and thus would disrupt both terrestrial and marine habitats.[98] Delaware regulators have rejected the proposed facility, but BP continues to press for its construction.[99]

Natural gas transported through pipelines requires the destruction of habitat for the pipeline itself and for associated maintenance roads. For example, the Williams Companies' Transco line from South Texas

to New York City that provides much of New Jersey's natural gas is 10,560 miles long.[100] Although the pipeline itself is narrow, its length and the disruption of the surrounding areas during construction means that its swath of habitat disturbance is substantial. At least two other major pipelines serve New Jersey.[101]

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.[102] 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.[103]

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.[104] When the land in question is already used for intensive agriculture, then

Table 4. Sources of Avian Collision-Deaths[112]

Source	Low Estimate	High Estimate	Volume of Related Facilities
Buildings & 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
Powerlines	tens of thousands	174 million	500,000 major transmission lines
Wind generation facilities	10,000	40,000	15,000 turbines

the wildlife impact and habitat loss is minor. In more remote areas, the disruption from a wind farm will be more significant.

For offshore wind power, the area of habitat lost permanently depends on how the turbines are anchored to the sea floor; typically the turbine footprint is 200 square feet though it can be as large as 1,500 square feet.[105] Temporary habitat loss results from the disturbance caused by laying the cables connecting the turbines to shore.[106] Additionally, offshore energy facilities alter marine habitats by creating artificial reefs that provide a base for algae, attracting invertebrates and fish.[107]

Presumably, construction of offshore wind projects could present some of the same risks of disturbance to marine wildlife that have been posed by oil and natural gas platforms, but no wind-specific studies of this have been completed.[108] It is likely that these impacts would be less severe for wind platforms, since wind turbines typically are attached to concrete foundations eight to 35 feet deep but do not require the elaborate platform necessary for oil and gas production and thus involve less construction.[109] Wind does not pose the threat of spills and toxic releases that routinely occur with oil and gas drilling.

Onshore or offshore, 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.[110]

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.[111] Even as more turbines are installed, properly sited wind power plants will cause only a small fraction of overall avian collision-deaths each year.

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.[113] 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.[114]

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 radically change coastlines and beloved ocean vistas, alter what plants will grow and when they undergo seasonal changes, and affect what birds can be sighted in New Jersey.

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

A nuclear power plant.

Nuclear Power

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

Sandy Ridlington

A natural gas power plant.

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.[115] 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.[116]

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 5 for comparison of noise impacts.) The wind itself may mask any noise produced by the turbine.

Table 5. Relative Volume of Wind Turbine Versus Other Common Sources of Noise[117]

Source	Distance (feet)	Sound Level (decibels)
Jet engine	200	12
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

20 turbines, rated at 2 MW each, in Denmark's Middelgrunden Offshore Wind Farm.

Guidelines for Wind Power in New Jersey

As New Jersey's energy demand grows, the state needs to pursue clean sources of electricity to keep our lights on, our homes warm, and our businesses running. Wind power development in New Jersey should be supported where the opportunities for productive, environmentally responsible facilities occur.

On the national and statewide level, wind power generation has less significant impacts than do other electricity generating options. Any specific wind project, however, will have impacts that must be evaluated. An appropriate wind project permitting process will allow decision makers and the public to weigh the local impacts of a wind development against the broader effects of continued reliance on traditional and polluting electricity sources and ensure that any impacts from energy development are kept to a minimum.

Reaching agreement on what reviews the permitting process should entail, how they should be conducted, and who should oversee them potentially can be a lengthy procedure. New Jersey, which suffers from high levels of air pollution and already experiences the early stages of global warming, does not have the luxury to spend years establishing the process by which proposed wind projects will be reviewed and permitted. Fortunately, other states already have grappled with this and have developed reviews that allow for the timely consideration of proposed wind projects. New Jersey can draw upon their experience to quickly establish its own process and to reduce the state's reliance on dirty power sources.

Elements of a Good Permitting Process in New Jersey

For New Jersey, a good permitting process will allow the state to expeditiously develop its wind resources without imperiling wildlife populations or damaging sensitive habitats. Whether the proposed wind development is within state jurisdiction or on federal land, the important elements remain the same. Following are guidelines for the key elements to include in New Jersey's review process for wind energy development.

Wind Projects in Federal Waters

New Jersey has the authority to decide when and how wind energy developments should be constructed in the state and up to three miles off the state's coast. Beyond the three-mile limit, however, the federal government has jurisdiction. Because projects in federal waters will have an impact on New Jersey, the state should recommend to federal decision makers that projects in federal waters adhere to the following guidelines:

- New Jersey state agencies and the public at large should have an opportunity to review and comment on any project off the state's coast.
- Renewable energy developments are fundamentally different from resource extraction projects in that renewable power has minimal impacts compared to the known damage and risks of oil and gas drilling. Regulations should take into account the differences in environmental impacts as well as the necessity for clean energy sources for New Jersey's future energy needs.
- Any leases granted to renewable energy developers by the federal government should reflect the lower impacts and risks of renewable energy compared to traditional energy projects.
- As with any energy project, renewable energy developments should be protected by existing environmental standards included in the National Environmental Policy Act, the Coastal Zone Management Act, the Endangered Species Act, the Marine Mammal Protection Act, and the Magnuson-Stevens Fisheries Conservation and Management Act. Projects should not be built in environmentally sensitive areas.
- Any leases should include plans for the full removal of the facility at the end of its usable lifetime.

Clear Decision Criteria

The conditions according to which a proposed wind installation will be approved or rejected should be clearly articulated in advance.[118] This will allow the project developer to know what requirements must be satisfied for the project to be approved. Members of the public who comment will be able to focus their remarks on how the project does or does not meet the relevant criteria. Additionally, establishing standards in advance will provide assurance to both the developer and the public that the requirements will not change in the course of the project review. And clear criteria will enable the regulatory agency to produce decisions that are consistent from one wind project to another and thus less likely to face legal challenge.

The following components of the review process should be established in advance:

- What factors will be considered? Environmental impacts, overall suitability of the site, impact on future wind projects, and impact on local community are often included.
- What are the minimum requirements that a project must meet?
    - o A project should have no significant environmental or public health impacts. If it does have negative consequences, the developer must include a mitigation plan to render the impacts insignificant.[119]
    - o Wind power facilities should not cause long-term declines in local, regional, or flyway populations.[120]
    - o The development must not kill any endangered species, either by destroying habitat or by creating a substantial collision risk. Data must be collected to evaluate these factors. Site studies can assess impacts on birds and other wildlife. The state should lay out guidelines for how to best assess the potential wildlife impacts, including how long studies should last and what methods should be used.
    - o Visual impacts can be evaluated through computer renderings of the project, and noise studies can determine if nearby homes and businesses will hear the turbines.
- Will the factors be weighted or ranked or will each aspect be given equal consideration?

Oregon has established criteria for permitting wind power developments by modifying existing energy facility standards, an approach that obviated the need to develop wind-specific guidelines and allowed immediate yet responsible development of wind farms. The state of Washington took a different approach. There, the state Department of Fish and Wildlife, the wind industry, and environmental activists spent nearly a year reaching agreement on an appropriate process. The coalition agreed to revisit the guidelines in five years after data has been collected from the first wind farms to confirm that the recommendations have been adequately protective of natural resources. (See text box on page 35 for more details.) In both states, however, wind developments are evaluated by clear criteria.

Timeline for Decision

The review process should occur according to a schedule predetermined by the permitting agency and the developer. Once the developer submits a complete permit application, the timeline goes into effect. This allows the public and interested groups to anticipate public hearings and review periods. Developers also appreciate knowing that the permitting process will not drag on for so long that it jeopardizes financing for the project.

Wisconsin's permitting process provides one example of such a timeline. Once an application with environmental reviews and mitigation measures is submitted and considered complete, the Environmental Quality Board, the permitting agency, has 45 days in which to recommend that the project be approved or denied. If the board recommends acceptance, it then has 180 days to draft a permit and allow public comments. At the end of that period, the board issues a final permit with any necessary restrictions.[121]

The timeline should be comparable to that established for review of similar projects, such as traditional electricity-generating facilities.

Adequate Opportunity for Public Participation

The public should be notified about any application for a wind project. The agency reviewing the permit should make both the draft and final plans available for public review, hold public meetings, and accept written public comment.[122] The public

meetings should be held at hours that allow the most citizens to attend and should be located in the communities that would be most affected by the project.

Comparison to Alternatives

The environmental review of a proposed new shopping mall or housing complex would compare the proposed action against the alternatives, such as a different location or configuration, or doing nothing. A review of a wind project should also evaluate the project in the context of alternative options.

One alternative for a wind project is to site it in a different place. It could be on the next ridge over or in a different location offshore. Or perhaps the location is generally acceptable but the project needs to be scaled back to reduce its impacts. All possible alternatives should be included in the scope of the review. This allows regulators and the public to consider several options for non-polluting energy generation.

The "no action" alternative that is possible for a shopping mall or road does not exist for a wind project. Another power-generating facility will be constructed somewhere and will affect New Jersey with air pollution, global warming, and other negatives. Thus, the "no action" alternative should consider the impacts—from fuel extraction to energy production to use of power lines—of producing power through other methods. The Board of Public Utilities, officials from PJM (the regional electricity transmission organization), and other experts should be consulted to determine the exact impacts of a "no action" alternative.

Review by Independent Staff with Technical Expertise

Ideally, the agency reviewing a proposed wind project will have adequate resources and staffing to conduct its own review of the proposal, rather than having to simply accept the developer's assessment. Staff with technical expertise can evaluate the planned project for its environmental, engineering, public health and safety qualifications and impacts.

In California, such review is conducted by the California Energy Commission, the body responsible for detailed, independent scrutiny of any project that will produce 50 MW of electricity or more.[123] In Oregon, the Office of Energy (OOE) helps the Oregon Energy Facility Siting Council, an appointed citizen commission, review proposed power facilities. OOE staff have the authority to hire additional technical consultants when necessary and pay them with funds provided by the project developer.[124]

Compliance Standards

Once the project is approved and specific terms have been agreed upon by the developer and the regulatory agency, those agreements should be included in the permit. The terms written into the permit for each step of the project should be specific, measurable, and enforceable.

The components of the permit should be enforced as the development proceeds to ensure full compliance. At each step, the agency overseeing the project should confirm that the developers have adhered to their commitments.

Post-Construction Monitoring

The permit should also specify how the project's wildlife and avian impacts will be measured once the plant begins to operate. The project developer and regulator should agree upon the monitoring protocol: for how many days each year, for how many years, over what size study area, and other details. The data should be detailed enough to allow the plant operator to track bird deaths at each specific turbine. If just one turbine causes significant mortality, then it can be removed, protecting birds and allowing the plant to continue providing clean power.

Washington Department of Fish and Wildlife Guidelines

The Washington Department of Fish and Wildlife (DFW) issued highly restrictive wind power siting guidelines in February 2002 that fulfilled the department's primary goal of protecting the state's wildlife resources but essentially precluded any wind power development.[126] The Renewable Northwest Project (RNP)—a coalition of consumer groups, environmental organizations and renewable energy companies—spent nearly a year working with DFW, Washington Audubon Society, wind developers and other interested parties to reach agreement on guidelines that both protect wildlife and allow wind power development.

RNP and the wind industry identified several points of concern with DFW's initial guidelines. Overall, the coalition felt that DFW's guidelines required mitigation measures that were disproportionate to impacts of wind power, were not supported by any scientific basis, were not applied consistently to different projects, and had been developed without input from affected parties. RNP and its allies also objected to some of the specifics of the guidelines, such as the requirement of one full year of bird studies before construction, a high ratio of replacement to affected habitat, and a blanket recommendation against any project on a ridgeline.

DFW, RNP, and industry ultimately agreed upon the following contested points:

- Environmental reviews will include reviews of existing information on species and habitat types in the wind resource area, mapping of those resources, and an avian impact study for at least one season (preferably the season of greatest bird presence).
- A technical advisory committee, with representatives from wildlife agencies, industry, environmental advocates and landowners, will analyze the results of ongoing monitoring data once a project begins operation. The committee will make recommendations on possible adjustments in the plant's operation to reduce its impact on birds and other wildlife.
- Habitat mitigation requirements will vary according to the quality of the habitat harmed by the wind plant or the duration of the impact (whether temporary due to construction or long-term for the life of the plant).

DFW agreed to adopt the guidelines as a five-year pilot program, during which time presumably at least one project will be conceived, approved and built. After the five-year trial period, the guidelines may be revised to incorporate new information gathered from the operating wind farms.

New Jersey could use Washington's guidelines as its own starting point, modifying requirements to meet the state's unique characteristics and then adopting the policies for a multi-year trial period.

The state of Oregon has required comprehensive monitoring of the Stateline Wind Project for the first two years of the project's operation, and potentially longer depending on the outcome of the first two years.[125] The bird fatality surveys will include searcher efficiency and bias estimates. Post-construction monitoring will also include surveys of raptor nesting and of burrowing owls, and assessments of habitat quality.

Post-construction monitoring results should also be made available to the public, regulators, and researchers. Wildlife is a resource for the public to enjoy both actively and passively and it is their right to know what impact a private development will have on that resource. Regulators need to know how a current development affects birds so that they can weigh that information in deciding whether to permit another facility. Researchers can compile study results from multiple wind farms to draw broader conclusions about how wind farms impact birds and how birds respond to different kinds of towers, sites and placement patterns.

Information Sharing

In the absence of a detailed, government-led study of all environmental considerations, project developers who conduct their own site-specific studies should share the results of their investigation. This will give regulators and the public more information about baseline conditions at the site so that impacts of the wind project can be evaluated. It will aid regulators who will be making decisions about subsequent wind projects and needing to consider the cumulative effects of all projects. Ideally, all studies should apply standard methods to allow for comparisons between studies.

The Next Steps for New Jersey

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

Wind farms are increasingly common both across the United States and around the world. To date, commercial wind developments have been built in 29 states, from hills in California to flat farmland in the Midwest to ridges in Pennsylvania and New York, as well as in a variety of coastal and offshore locations in Europe. While data that has been gleaned from these operations is in some ways site-specific, much is known about general principles that can guide decisions about where to allow, or not allow, a wind farm to be sited on the East Coast.

Gathering full information about the impacts of wind power development in New Jersey, however, will require that some projects be developed along the East Coast and begin providing data. New Jersey should move forward quickly with approving the state's first small wind projects, including a pioneering offshore wind facility. Developing a small test project that can be closely studied will provide the region-specific data New Jersey needs before moving forward with large-scale development. Carefully chosen and closely monitored local projects will ensure the environmental integrity of those and future developments.

New Jersey does not have to start from scratch in developing guidelines for reviewing either a test project or all proposed projects. It can begin by looking at the processes other states successfully use to review projects. In the course of building this first project, regulators and the developer will begin to gather information about impacts of building wind farms in the state. Detailed studies of the operating project will help quantify the impacts, particularly on migratory birds, suggest important modifications and mitigation steps, and inform decision-making for future wind developments.

To aid in applying the data collected from this first plant, New Jersey should conduct a statewide survey of other potential wind development sites. This survey will help determine how and where to apply the data gathered from newly constructed wind farms.

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 New Jersey and for our country that our larger neighboring states have already begun to tap. New Jersey cannot afford to forego opportunities within our own borders for the development of this nonpolluting source of energy.

Appendix A. Agencies Involved in Wind Projects

What level of government has jurisdiction and what agencies need to be involved in reviewing a proposal to develop a wind project depends on where that project will be located, how big it will be, and what habitat and wildlife it might impact.[127]

Wind projects on shore in New Jersey must be reviewed by several agencies. The municipality in which the proposed facility will be built must approve the plan, confirming that it complies with zoning and land use regulations.[128] The local conservation district might need to issue a permit for soil erosion. The Department of Community Affairs will review the plan to ensure the buildings are structurally sound. A facility proposed for coastal areas in the southern part of the state will be subject to provisions of the Coastal Area Facility Review Act (CAFRA), which involves a detailed environmental review conducted by the Department of Environmental Protection. The Federal Aviation Administration will be involved if the turbines are over 200 feet tall.[129]

Projects offshore require the federal government's involvement but may also include the state if the project is less than three miles offshore. The Army Corps of Engineers is the permitting authority that oversees projects that occur in navigable waters and conducts reviews required by the National Environmental Policy Act.[130] The U.S. Fish and Wildlife Service enforces the Migratory Bird Treaty Act, the Interior Department carries out the provisions of the National Historic Preservation Act, the Federal Aviation Administration provides guidelines for how towers must be marked, and the National Marine Fisheries Service oversees protections of fishing stocks up to 200 miles offshore.[131] The precise role of each of these agencies and the potential role of state authorities has not yet been clarified.

Whether the agencies involved are state or federal level, the considerations discussed in the section "Elements of a Good Permitting Process" should apply to the review process for determining the impacts and mitigation requirements for any wind power plant that is 25 MW or larger.

Fig. 6. Federal Agencies that May Be Involved in Reviewing Proposed Offshore Wind Projects[132]

Agency	Legislative Authority
Army Corps of Engineers	National Environmental Policy Act Outer Continental Shelf Lands Act Rivers and Harbors Act
Coast Guard	Navigation and Navigable Waters
Council on Environmental Quality	National Environmental Policy Act
Department of the Interior	National History Preservation Act
Environmental Protection Agency	National Environmental Policy Act
Federal Aviation Administration	Navigational Hazard to Air Traffic
Fish and Wildlife Service	Endangered Species Act Estuary Protection Act Fish and Wildlife Coordination Act Marine Mammals Protection Act Migratory Bird Treat Act
Minerals Management Service	Outer Continental Shelf Lands Act Submerged Lands Act
National Marine Fisheries Service	Endangered Species Act Fish and Wildlife Coordination Act Marine Mammals Protection Act
National Ocean Service	National Marine Sanctuary Act

Appendix B. 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.[133]

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.[134] 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.[135] Songbirds often migrate at 500 to 1,000 feet; most other birds migrate at an altitude of 1,500 to 2,500 feet.[136] 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.[137]

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.[138]

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.[139] Rotors on older turbines spin at a rate of 60 to 80 revolutions per minute, too fast for birds to see the blades.[140] 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.[141]

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.[142]

Construction can be timed to avoid periods of peak use by birds, such as during the spring migration season.[143]

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.[144] 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.[145]

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.[146]

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.

Notes

1. Board of Public Utilities, *NJ Electricity Consumption vs. Current Class I and II RPS Requirements*, downloaded from www.bpu.state.nj.us/renewenergy/rpscharts.pdf, 26 October 2003.

2. U.S. Environmental Protection Agency, *Emissions and Generation Resource Integrated Database v 2.01*, 9 May 2003.

3. See note 1.

4. Energy Efficiency and Renewable Energy, U.S. Department of Energy, *New Jersey Wind Resources*, downloaded from www.eere.energy.gov/state_energy/tech_wind.cfm?state=NJ, 29 January 2004.

5. Neil Habig, et al, Atlantic Renewable Energy Corporation and AWS Scientific for New Jersey Department of Environmental Protection, *New Jersey Offshore Wind Energy, Feasibility Study, Final Version*, December 2004.

6. Kevin Smith, AWS Scientific, presentation to NWCC on 25 September 2002, summarized in NWCC, B*asic Overview of Offshore Wind Energy Development for the Production of Electricity, Draft Meeting Summary*, 6 January 2003.

7. Solar and some forms of biomass also can provide clean, renewable energy. However, each has its limitations—solar is not yet cost-competitive and biomass creates some pollution—and, as this paper focuses on developing New Jersey's wind resources, we will not try to evaluate other renewable energy sources here.

8. U.S. Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2002*, October 2003.

9. U.N. Intergovernmental Panel on Climate Change, *Climate Change 2001: The Scientific Basis*, February 2001.

10. James McCarthy, et al, "Climate Change 2001: Impacts, Adaptation, and Vulnerability," *Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, 2001.

11. U.S. EPA, *Global Warming Impacts: State Impacts—New Jersey*, 7 January 2000.

12. See note 10.

13. See note 11.

14. Ibid.

15. U.S. EPA, Office of Policy, *Saving New Jersey's Vanishing Shores*, July 1999.

16. U.S. Environmental Protection Agency, *Global Warming Impacts: Coastal Zones*, downloaded from yosemite.epa.gov/oar/globalwarming.nsf, 16 October 2003.

17. See note 11.

18. See note 16.

19. James Titus and Charlie Richman, "Maps of Lands Vulnerable to Sea Level Rise: Modeled Elevations Along the U.S. Atlantic and Gulf Coasts," *Climate Research*, 2001, as cited in U.S. Environmental Protection Agency, *Maps of Lands Vulnerable to Sea Level Rise*, downloaded from

yosemite.epa.gov/oar/globalwarming.nsf, 16 October 2003.

20. Ibid.

21. Ibid.

22. See note 11.

23. See note 16.

24. New Jersey Division of Fish and Wildlife, *Least Tern, Sterna antillarum*, downloaded from www.nj.gov/dep/fgw/ensp/pdf/end-thrtened/leasttern.pdf, 19 November 2003.

25. See note 16.

26. C.J.J. Hull and James Titus editors, U.S. EPA and Delaware River Basin Commission, *Greenhouse Effect, Sea Level Rise, and Salinity in the Delaware Estuary*, 1986.

27. Ibid.

28. Eric Avedissian, *Cape May's Desalination Plant's No Albatross,* downloaded from www.capemay.com/desalination, 29 December 2003.

29. Q.K. Ahmad, et al, "Summary for Policymakers, Climate Change 2001: Impacts, Adaptation, and Vulnerability," *A Report of Working Group II of the Intergovernmental Panel on Climate Change*, February 2001.

30. See note 10.

31. Ibid.

32. Ibid.

33 American Bird Conservancy and National Wildlife Federation, *Birdwatcher's Guide to Global Warming*, 2002.

34. U.S. EPA, *Global Warming Impacts: State Impacts—New Jersey*, 7 January 2000; and New Jersey Pinelands Commission, *Pine Barrens Treefrog*, downloaded from www.state.nj.us/pinelands/treefrog.htm, 19 November 2003.

35. See note 11.

36. Assuming CO2 levels reach concentrations double that of the pre-industrial climate. American Bird Conservancy and National Wildlife Federation, *Global Warming and Songbirds: New Jersey*, 2002.

37. Ibid.

38. See note 10.

39. Alan Springer, Institute of Marine Science, University of Alaska Fairbanks, "Is It All Climate Change? Why Marine Bird and Mammal Populations Fluctuate in the North Pacific," *Biotic Impacts of Extratropical Climate Variability in the Pacific*, National Oceanic and Atmospheric Administration and the University of Hawaii, 1998.

40. See note 10.

41. United Nations Environment Program, *UNEP and Marine Mammals*, downloaded from www1.unep.org/marine-mammals, 2 December 2003.

42. Carbon dioxide emissions are based on energy consumption data obtained from the EIA at www.eia.doe.gov/emeu/states/sep_fuel/notes/_fuelnotes_multistate.html. Energy consumption for each fuel in each sector (in BTU) was multiplied by carbon coefficients (EIA, Emissions of Greenhouse Gases in the United States 2002) to calculate the emission from each activity.

43. See note 2.

44. Carbon dioxide emissions are based on energy consumption data obtained from the EIA at www.eia.doe.gov/emeu/states/sep_fuel/notes/_fuelnotes_multistate.html. Energy consumption for each fuel in each sector (in BTU) was multiplied by carbon coefficients (EIA, *Emissions of Greenhouse Gases in the United States 2002*) to calculate the emission from each activity. Carbon dioxide emissions from cars and light trucks calculated as 92 percent of motor gasoline use, per EIA, *Supplemental Tables to Annual Energy Outlook 2003*. Vehicle registration information from Federal Highway Administration, *Highway Statistics 2001*, *Table MV-1*, October 2002.

45. See note 8.

46. See note 44.

47. See note 2.

48. New Jersey Public Interest Research Group, "Clean Air Advocates Call for Urgent Action on Air Pollution" (press release), December 2003.

49. There were 281 violations in 2002. Emily Figdor, *Danger in the Air: Unhealthy Levels of Smog in 2003*, U.S. PIRG Education Fund, September 2004.

50. Environmental Protection Agency, *Region 2: State Designations, Boundary Desginations for 8-Hour Ozone Standard*, 15 April 2004.

51. National Wind Coordinating Committee, *Permitting of Wind Energy Facilities: A Handbook*, revised August 2002.

52. Abt Associates, *Out of Breath: Health Effects from Ozone in the Eastern United States*, 1999.

53. Clean Air Task Force, *Death, Disease, and Dirty Power*, October 2000.

54. See note 51.

55. U.S. EPA, *Tier Emissions Report—Criteria Air Pollutants*, database searched 20 November 2003.

56. New Jersey Mercury Task Force, Department of Environmental Protection, *Volume III: Sources of Mercury in New Jersey*, January 2002.

57. Minnesota Office of Environmental Assistance, *Reducing Mercury in the Environment*, www.moea.state.mn.us/berc/mercury.cfm, 28 February 2005.

58. U.S. EPA, *Mercury Study Report to Congress*, 1997.

59. U.S. EPA, Region 2, *Mercury in the Environment: Sources, Health Impacts, and What Can Be Done*, downloaded from www.epa.gov/region02/health/mercury.htm, 2 December 2003.

60. U.S. Environmental Protection Agency, *Emissions and Generation Resource Integrated Database v 2.01*, 9 May 2003; total emissions data from U.S. EPA, *Tier Emissions Report—Criteria Air Pollutants*, database searched 20 November 2003.

61. Ibid.

62. See note 2.

63. Pace University, *Power Scorecard: Electricity From Coal*, revised 9 September 2003.

64. Walter Rossman, Ed Wytovich, and James Self, *Abandoned Mines—Pennsylvania's Single Biggest Water Pollution Problem*, Pennsylvania Department of Environmental Protection, 21 January 1997.

65. NJPIRG Law and Policy Center, *Unnecessary Risk; The Case for Retiring Oyster Creek Nuclear Power Plant*, April 2003.

66. Minerals Management Service, U.S. Department of the Interior, *Gulf of Mexico OCS Oil and Gas Lease Sale 181, Draft Environmental Impact Statement*, 2000.

67. Peter Goldman, Program Manager, U.S. Department of Energy, Wind and Hydropower Technologies, *Wind Energy: Moving Offshore*, presentation to National Wind Coordinating Council meeting, July 2003.

68. U.S. PIRG, *Lethal Legacy: The Dirty Truth About the Nation's Most Polluting Power Plants*, April 2000.

69. U.S. Environmental Protection Agency, *Progress Report on the EPA Acid Rain Program*, November 1999.

70. Mary Gastrich, *Harmful Algal Blooms in Coastal Waters of New Jersey*, NJ DEP, May 2000.

71. U.S. EPA, *Deposition of Air Pollutants to the Great Water: Second Report to Congress*, (EPA-453-R-97-011), 1997.

72. U.S. Nuclear Regulatory Commission, "PSEG Nuclear LLC; Salem Nuclear Generation Station, Environmental Assessment and Finding of No Significant Impact," *Federal Register*, 15 May 2001.

73. American Nuclear Society, "Discharge Mishap Results in Large Penalty," *Nuclear News*, February 2003.

74. See note 60.

75. *What Is Coal Ash?*, Coal Ash Resource Center, University of North Dakota, downloaded from www.eerc.und.nodak.edu/carrc/html/whatiscoalash.html, 24 October 2003.

76. "Questioning Coal Ash Deregulation," *Environmental Health Perspectives*, November 2000.

77. *Coal Ash*, Wisconsin Public Service, downloaded from www.wisconsinpublicservice.com/news/ash.asp, 24 October 2003.

78. See note 76.

79. Ibid.

80. Michael Long, "Half-Life: The Lethal Legacy of America's Nuclear Waste," *National Geographic*. July 2002: 2-33.

81. Nuclear Regulatory Commission, *Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants*, October 2000.

82. Brookhaven National Laboratory, *A Safety and Regulatory Assessment of Generic BWR and PWR Permanently Shutdown Nuclear Power Plants*, August 1997.

83. Matthew Bunn, et al, *Interim Storage of Spent Nuclear Fuel: A Safe, Flexible, and Cost-Effective Near-Term Approach to Spent Fuel Management*, Managing the Atom Project, Harvard University, and Project on Sociotechnics of Nuclear Energy, University of Tokyo, 2001.

84. Linda Ashton, "State Warns of Suit over Hanford Cleanup," *Seattle Times*, 24 March 2001.

85. Public Citizen, *Impacts of Nuclear Waste Transportation*, downloaded from www.citizen.org/cmep/RAGE/radwaste/factsheets/45-trans.htm, 2 September 2001.

86. BirdLife International, *Windfarms and Birds: An Analysis of the Effects of Windfarms on Birds, and Guidance on Environmental Assessment Criteria and Site Selection Issues*, commissioned by the Council of Europe for the Bern Convention, 15 October 2002.

87. D. Maehr and J. Smith, "Bird Casualties at a Central Florida Power Plant: 1982-1986," *Florida Field Naturalist*, 1988, as cited in Wallace

Erickson, et al, *Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparison to Other Sources of Avian Collision Mortality in the United States*, National Wind Coordinating Committee, August 2001.

88. "Songbird Population Declines Linked to Acid Rain, Cornell Ecologists Report," *Cornell News*, 15 August 2002.

89. Wallace Erickson, et al, *Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparison to Other Sources of Avian Collision Mortality in the United States*, National Wind Coordinating Committee, August 2001.

90. C. Faanes, "Bird Behavior and Mortality in Relation to Power Lines in Prairie Habitats," *fish and Wildlife Technical Report*, U.S. Department of the Interior, Fish and Wildlife Service, 1987, and F. B. J. Koops, "Collision Victims of High-Tension Lines in the Netherlands and Effects of Marking," *KRMA Report 01282-MOB*, 1987, both cited in Wallace Erickson, et al, *Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparison to Other Sources of Avian Collision Mortality in the United States*, National Wind Coordinating Committee, August 2001.

91. Pace University, *Power Scorecard: Electricity From Coal*, revised 9 September 2003.

92. Walter Rossman, Ed Wytovich, and James Self, *Abandoned Mines—Pennsylvania's Single Biggest Water Pollution Problem*, Pennsylvania Department of Environmental Protection, 21 January 1997.

93. Citizens Coal Council, *Mountaintop Removal Strip Mining*, downloaded from www.citizenscoalcouncil.org/facts/mtntop.htm, 24 October 2003.

94. Defenders of Wildlife, *Cerulean Warbler*, downloaded from www.kidsplanet.org/factsheets/ceuwarbler.html, 6 November 2003.

95. Hans Sorensen, SPOK ApS, presentation to NWCC on 25 September 2002, summarized in NWCC, B*asic Overview of Offshore Wind Energy Development for the Production of Electricity*, *Draft Meeting Summary*, 6 January 2003.

96. Liesbeth de Bakker, Radio Nederland, *Oil Rigs Confuse Migrating Birds*, 15 May 2001.

97. R. Bjorge, "Bird Kill At An Oil Industry Flare Stack in Northwest Alberta," *Canadian Field-Naturalist*, 1987, as cited in Wallace Erickson, et al, *Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparison to Other Sources of Avian Collision Mortality in the United States*, National Wind Coordinating Committee, August 2001.

98. "BP Planning New Jersey LNG Terminal," *The Energy Daily*, 9 December 2003.

99. Terrence Dopp, "BP Appeals LNG Pier Rejection," *Today's Sunbeam*, 16 February 2005.

100. *Natural Gas Pipelines*, Williams Companies, 2003.

101. "Big Impact Likely From Planned U.S. East Coast LNG Terminals," *World Gas Intelligence*, 8 December 2003.

102. "New Jersey Renews Nuclear Plant's Water Permit Despite Fish Kills," *Environmental News Network*, 19 July 2001.

103. See note 86.

104. See note 51.

105. Bald Eagle Power Company, *Frequently Asked Questions*, downloaded from www.baldeaglepower.org/faq.html, 26 January 2004.

106. See note 86.

107. Texas Parks and Wildlife Department, *Artificial Reefs*, downloaded from www.tpwd.state.tx.us/fish/reef/artreef.htm, 24 January 2005.

108. Bruce Bailey, AWS Scientific, presentation to NWCC on 25 September 2002, summarized in NWCC, B*asic Overview of Offshore Wind Energy Development for the Production of Electricity*, *Draft Meeting Summary*, 6 January 2003.

109. See note 51.

110. National Wind Coordinating Committee, *Wind Turbine Interactions with Birds and Bats: A Summary of Research Results and Remaining Questions*, *Fact Sheet*, *Second Edition*, November 2004.

111. See note 89.

112. Ibid.

113. See note 86.

114. Ibid.

115. National Wind Coordinating Committee, *Avian/Wind Turbine Interaction: A Short Summary of Research Results and Remaining Questions (factsheet)*, December 2002.

116. Jean Vissering, *Wind Energy and Vermont's Scenic Landscape: A Discussion Based on the Woodbury Stakeholder Workshops*, downloaded from www.state.vt.us/psd/ee/ee.html, 7 October 2003.

117. Paul Gipe, *Wind Energy Comes of Age*, 1995, as cited in National Wind Coordinating Committee, "Wind Energy Environmental Issues," *Wind Energy Series*, January 1997.

118. The discussion in this section is informed by the outline of permitting in National Wind Coordinating Committee, *Permitting of Wind Energy Facilities: A Handbook*, revised August 2002.

119. See note 51.

120. Audubon Washington, *Policy on Wind Power Facilities*, 23 September 2002.

121. Minnesota Environmental Quality Board, *Wind Turbine Siting*, downloaded from www.eqb.state.nm.us/energyfacilities/wind.html, 30 December 2003.

122. National Wind Coordinating Committee, "Siting Issues for Wind Power Plants," *Wind Energy Series*, January 1997.

123. California Energy Commission, *Energy Facilities Licensing Process: A Guide to Public Participation*, downloaded from www.energy.ca.gov/siting guide_license_process.html,

3 October 2003.

124. See note 51.

125. Ibid.

126. The information is this section is drawn from Sonja Ling and Andy Linehan, *Wind and Wildlife in Washington: Negotiating Changes to the Washington Department of Fish and Wildlife's Wind Power Guidelines*, Renewable Northwest Project and CH2M Hill, May 2003.

127. Bonnie Ram, Energetics, *Offshore Wind Developments in the United States: Regulations and Jurisdictions*, presentation to NWCC, July 2003.

128. George Riepe, Assistant Director, Energy Division, New Jersey Board of Public Utilities, personal communication, 31 October 2003.

129. Steve Huntoon, Project Manager, Community Energy, personal communication, 17 October 2003.

130. See note 127.

131. Ibid.

132. Ibid.

133. Other concerns about wind installations potentially include noise and other disruptions—such as increased traffic—during construction, and noise during operation. Questions may arise whether a project is an appropriate land use for an area—wind farms can seem industrial and the best wind resource areas are not necessarily zoned as industrial land. Landowners may worry that a wind farm, either onshore or offshore, might hurt their property values, or fear that because their neighbor has leased land to a wind developer their own chances of siting a wind farm have been reduced. Concerns about the safety of the facility and transmission lines, soil erosion, and effects on cultural and historical resources may arise also.

134. See note 115.

135. Ibid.

136. See note 51.

137. A. Spaans, et al, "Windturbines en vogles: hoe hiermee om te gaan?" *Levende Natuur*, 1998, as cited in BirdLife International, *Windfarms and Birds: An Analysis of the Effects of Windfarms on Birds, and Guidance on Environmental Assessment Criteria and Site Selection Issues*, commissioned by the Council of Europe for the Bern Convention, 15 October 2002.

138. See note 115.

139. See note 86.

140. See note 115.

141. W. Hodos, *Minimization of Motion Smear: Reducing Avian Collisions with Wind Turbines, 12 July 1999 to 31 August 2002*, National Renewable Energy Laboratory, August 2003.

142. U.S. Fish and Wildlife Service, *Service Interim Guidelines for Recommendations on Communications Tower Siting, Construction, Operation, and Decommissioning*, 21 November 2000.

143. See note 95.

144. See note 86.

145. Ibid.

146. National Wind Coordinating Committee, "Wind Energy Environmental Issues," *Wind Energy Series*, January 1997.

Harriet Eckstein Graphic Design