Proceedings of
Wind Energy and Wildlife:
The Good, the Bad … the Possible

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INTRODUCTION TO THE PROCEEDINGS OF THE WIND ENERGY AND WILDLIFE SYMPOSIUM

New Jersey's population and energy consumption are growing. Over the next decade, the state's electricity demand is expected to grow by at least 14 percent. Though energy conservation and increased efficiency may help "supply" this need, it is highly likely that additional power generation will be needed to satisfy the demand.

Burning fossil fuels causes air pollution and water pollution, and releases global warming "greenhouse gases." Costs and impacts – associated with extraction, processing, transportation, and security – are additional results. As part of addressing future energy needs, New Jersey has adopted a goal of having twenty percent (20%) of its future electric needs supplied by renewable and clean resources. Wind energy has been identified as having a great potential to provide the clean electric power that New Jersey will need.

In recent years, several locations onshore and offshore have been identified for wind power development. However, the most productive wind resource in New Jersey is offshore. Because no wind power facilities have been constructed offshore along the East Coast of the United States, there is some uncertainty about the costs and benefits of such facilities.

This one-day workshop was designed to explore the ecological benefits and risks associated with wind-produced energy, and assist stakeholders in developing scientifically sound policies pertaining to the development of wind energy in New Jersey.

The workshop provided participants with a clear understanding of the benefits, and some potential drawbacks, of wind energy in New Jersey and the surrounding region in order to facilitate the development of sound policies governing its implementation. Issues discussed included markets, global warming and issues associated with wildlife. The reader should note that much of the information regarding wildlife focus on birds. This is merely a reflection of the particular speaker's expertise and not any indication that other wildlife based concerns (marine mammals, finfish, benthic animals) would need to be considered.

The symposium's steering committee included Ted Korth of the NJ Audubon Society, Kathy Bird of the NJ Audubon Society, Dr. David Wilcove of Princeton University and Dr. Michael Oppenheimer of Princeton University.

For more information or to obtain additional copies of this document call the New Jersey Audubon Society Conservation Department at (908) 766-5787.

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Dr. Franz Bairlein
Director, Institute for Avian Research
Professor of Zoology and Ecology, University of Oldenburg

Offshore wind power: pre-construction risk assessment for site selection, design and operation of wind turbines (a discussion of activities based on research in Germany). Annual yield in relation to wind speed increases dramatically offshore. Electrical prices are reduced, making the cost of wind energy very low. The highest yields are greatest farthest offshore and in deeper water (40m). This generates a lot of excitement for offshore wind energy; however, wildlife issues need to be considered. Currently there is no offshore wind power use by Germany, but this is expected to increase considerably in the upcoming years.

One of the issues to be addressed is very tall structures (200m in height) in an open sea. There are individual farms on schedule, with plans to set up wind turbines in a 25,000 km^2 area. The idea is to develop wind power in the North Sea area – an area heavily used by migrant Arctic shore birds. Consideration must be made for how turbines influence bird migration/flight. Specific issues include: collision risk, barrier effect and area desertion (due to habitat disturbance/destruction). We must consider these and ask how we can solve these in a pre-construction assessment study. Further, analysis must be done on a species-specific level considering the conservation concern of some of these species.

The Institute of Avian Research Island Station provides one route for understanding these impacts. One challenge in assessing the impacts of wind power is that a good deal of migration occurs at night. Radar offers one method of detecting night activity (such as altitude of migration). Thermal imaging provides a mechanism of identifying species.

One of the most surprising results concerns the flight altitude of migration. Most migration over water occurs very close to the sea surface. More than 70% of migration is below the height of the wind turbine structure. This is what we need to address in a pre-construction assessment study. We cannot extrapolate from onshore studies. Flight altitude is considerably different.

Given the size of the impacted area, it is also important to understand the habitat influence and the migration routes. To get a handle on this surveillance radar data can provide information on the large-scale spatial dimension of migration. This data uncover migratory corridors. Combine this pathway information with the flight altitude information then you can identify the possible risk to migrants over the North Sea. We must not forget that we also need to understand the distribution of seabirds at sea and habitat.

To do this we employ visual observations (boat, air) and conduct seabirds at sea surveys. This will identify concentration areas for a number of species as well as concentration at specific times of the year (fall migration, etc.). By constructing a sensitivity map (bird areas of concern) we can identify the best location for wind farms. Ultimately a wind farm sensitivity index can be calculated based on density at sea and species-specific sensitivity index (flight behavior, habitat use, population size and conservation status). This can be applied to offshore areas and identify areas of concern.

Already areas along the cost are areas of special concern – the recommendation would be not to set up wind turbines at these spots. The aim is to find compromises. The needs/concerns of both sides must be addressed for a win/win strategy.

Brent Beerley
Vice President
Community Energy, Inc.

PJM Wind Energy market has increased considerably over time and has great potential. Financing is an issue. Wind financing is $60/mw hour, based on equipment supplies, loss of federal tax benefits and value of the dollar. The value of wind energy is $40/45 in the market – this results in a net impact of $10/20 mw hour cost. How do you change this? Find visionary individuals, corporations and institutions that want to get wind energy on line.

The state of New Jersey is a notable visionary. Renewable Energy Credits (RECs) close the gap between market value and cost, and represent the attributes of wind energy and captures the premiums. Several programs have been initiated, such as PECO which has 12,000 individuals signed up for wind energy on their electric bill. The goal is to allow all electric customers in New Jersey make the decision to use renewable energy as their energy source. This has resulted in 200mw in wind supply that is either on line or being built this year in this region. The point is that without customers paying the gap between cost and market value wind energy would not be online.

System Structure: Wind farm is built if there is a long-term, credit worthy entity to manage the wholesale energy (known as the wholesaler). Customers inject the premiums on the energy cost which ultimately make the wholesaler comfortable in their revenue stream. An important part of this puzzle is the long-term creditworthy REC (consumer) purchases.

PJM GATS (Generation Attribute Tracking System) are designed to support verification of RPS, disclosure and voluntary market reporting and verification. They are non-jurisdictional to FERC. How does the mandate for renewable energy influence the voluntary market? In theory the RPS could shut down the system. The cost of $7 mw hr is not enough to finance wind farms but a voluntary market price can help wind farms. But the voluntary market is unlimited – many want more wind than the minimum, creating a positive influence on the future of wind energy. There is concern to let wind energy offset utilities requirement; the key is to keep separate the voluntary market and compliance market.

Test case: Atlantic City Wind Farm - A clean energy showcase visible to 30 million people per year. It took a little luck and a lot of patience. The project takes up zero undeveloped land. There will be five General Electric turbines that will produce 15,000 to 20,000 mwhr/year. Excess output will go off to the PJM grid as merchant energy. Advanced avian studies are being conducted to monitoring the effects of the wind farm.

Jack Clarke
Director of Advocacy
Massachusetts Audubon

The Cape Wind project consists of 130 turbines, spaced one-third to one-half mile apart spanning 25 square nautical miles. Max height to tip of blade is 425 ft above mean sea level. Cape Wind is an area of max winds. The building site is Nantucket Sound which places turbines roughly five miles from points of land. This is a highly controversial project because approximately 500,000 sea ducks spend six months of the year on the Sound.

Massachusets Audubon began base line data two years before the start of the project. This information can be peer reviewed along with the applicant's data. The high use of this area by ducks and endangered bird species are of concern for Mass Audubon. One of our premises is that the combustion of fossil fuels results in increased greenhouse effects. A climate protection plan seeks to reduce carbon emissions by 20% by 2025 by promoting energy efficiency and expanding renewable energy. The Cape Wind project is expected to produce 75% of energy for the Cape Code area. There will be an impact. Concerns also address the disturbance to the "clear horizon".

Mass Audubon analysis criteria: project can pose no unreasonable risk to endangered or threatened wildlife. The project cannot be set on any major migratory routes. Project construction cannot degrade the quality of the habitat. Appropriate planning and sitting criteria, monitoring protocols and adequate environmental mitigation measures need to be in place. Potential impacts must measured according to peer-reviewed protocols for pre, during and post construction monitoring. There must be well-defined mitigation measures and adequate compensation for use of public lands and waters by privately developed and financed wind farms. Regulatory approval for the wind farm project must include enforceable procedures and bonding authority for decommissioning abandoned facilities. The final position will be based on how the permitting authorities and applicant address the above factors. It will weigh the environmental pros/cons of the projects against the documented and substantial impacts associated with the extraction, transportation, use and disposal of fossil and nuclear fuels including the effects of rapid climate warming. Mass Audubon continues with this research as well as looking into what is occurring in Europe and other areas.

Richard Dunk
Research Scientist
Rutgers University Center for Environmental Prediction
Director of Coastal Laboratory for Applied Meteorology
Rutgers Institute of Marine and Coastal Sciences

The DOE wind map indicates that over an annual period, winds do increase offshore; however, over a shorter period things might be different. What we first need to identify is where the resource is viable for wind energy development. New Jersey is unique in that in the summer, populations dramatically increase along the coast. This ultimately impacts power demands – where will the wind come from? Can offshore support this? Again, annual average does indicate that winds are greater offshore but within these areas, we must consider the best area for maximizing wind energy.

In considering New Jersey, the wind resource is very different along the Jersey coast from north to south. Off of Great Bay (GB), there is a very good wind source, but at Long Beach Island (LBI), the annual wind resource is not very good. This is very important when we consider where the wind farm is produced – you need to be in the area of the wind resource to receive wind benefit. LBI and GB are not that far apart yet very different.

Using offshore platform data and onshore tower data provides a substantial database to understand wind resource in the Phase I/II area (GB). Phase III (Delaware Bay) is in progress in terms of understanding wind resources, and eventually there will be wind maps generated for a final, Phase V location that spans the cost and goes out to sea. The important point here is that these offshore wind maps be developed so that the appropriate individuals can focus in on the most appropriate location for wind development (grid resolution 2 km – model must be tested for higher resolution). Data is accumulated from off coast monitoring stations. For example, instruments are set at different levels along a 60-meter tower. Sonar and meteorological data is accumulated. The intent is to develop wind energy forecast model. A remote system is added to give us a good idea of what our wind resource is off shore.

Some of the modeling runs that have been performed show that wind intensity is strongest along the coast, decreases moving off shore, and if you get far enough out, intensity picks up. This means that building off shore is not as beneficial. Recalling that peak demand is in the summer, and the sea breeze along the shore, the intensity of the sea breeze coincides with peak energy demand (sea breeze increases throughout the day). The sea breeze intensity rises in the late afternoon and evening. As point of reference, sea breeze develops as a result of the land/sea temperature gradient. Land heats faster than the ocean, as a result, warm air over the land rises, cold air from over the ocean rushes in to replace it. This results in the development of a closed sea breeze circulation cell, making the sea breeze a thermally driven process.

Another thing that affects sea breeze is coastline topography. Sea breezes increase with the convex coastline (but decreases with a concave shoreline) – making wind energy potentially available at LBI when needed. As sea breeze develops it extends offshore as well, with a 10/15 mile off shore divergence followed by a sea breeze farther out to sea. Moving inward, sea breezes can extend beyond the coast and can influence the entire state. As the sea breeze moves inland it experiences a loss in intensity, so, in terms of wind energy/resources, the coast is the better location.

The point: The wind energy maps are correct in that the average wind energy is greatest along the coast; however, when you look at offshore wind resources you must take into account what happens with the sea breeze and peak energy demand. As a result of the unique interactions among the land, sea and atmospheric environment, a representative analysis of the offshore and coastal wind resource requires high-resolution modeling supported by in-situ monitoring and remote sensing.

Dr. Jeremy Firestone
Assistant Professor, Marine Studies
University of Delaware

Wind power is the fastest growing source of energy in the world today. It is important to understand why people support or oppose offshore wind. Focus has been to identify why people support or oppose offshore wind power and set forth considerations in the development of federal and state regulatory frameworks.

Preliminary Analysis of a Cape Cod survey on offshore wind power development suggests that support/opposition is relatively evenly split. There are a number of factors that influence support/opposition: age (older supports less); positive correlation in education with support; generally no income effect. There would have been more support if it were local government rather than private developer involved – why should a private developer determine activities on the Cape. People on the Cape were more likely to support the project if it were part of a larger implementation plan for the eastern coast. People would be less likely to support the project if it were on land and in their personal view.

Turning to the regulatory side, it is important to recognize that current laws regulating offshore wind were enacted without having the development of wind power in mind. Big issues to consider in a future offshore wind regime are: 1.) security of tenure. Banks are used to dealing with property rights of which there are none in the ocean (matter of federal law). 2.) Fair compensation should be made; rent, royalties? Some royalties should be shared among states. 3.) Public interest should be enhanced and there should be better requirements on closure. This includes decommissioning funding, performance bonding and closure requirements. 4.) On the federal side we have more than one "master of the ocean". We need one and will ultimately need some management and planning at the federal level.

In conclusion, in addition to all the environmental issues and finding out where the wind is, we need to think about what the public wants and getting a good legal and regulatory regime that considers public input.

Dr. Jeffery Greenblatt

Research Staff Member
Princeton Environmental Institute
Princeton University

Energy needs can be met through wind power. Wind presents a growth opportunity. Wind power production has generated 40,300 mw at end of 2003 – the projection by 2013 is 194,000 mw. Wind energy is a pollution free and carbon dioxide free source of electricity. Wind turbines may be installed rapidly, are inexpensive and approaching gas turbine cost of energy. Liabilities include limiting sighting, greater land occupancy than fossil fuels, intermittent output and transmission distances are often long. Implications of intermittent power output: need backup generation. This means fossil fuel must fill in gaps, increasing carbon dioxide emissions and the cost to maintain wind power. Does this then limit the penetration of wind power? Not necessarily.

Wind is not dispatchable meaning you cannot control the output. On average a typical wind farm is operating one-third of the power meaning that something else must fill in the gaps (usually gas turbines). Wind produces no carbon dioxide but only 35% of fraction of total energy/year while the gas turbine produces 120 gC/kWh) but more total energy. Compared to pulverized coal, which produces 300 gC/kWh). There are costs associated with intermittency. We can improve this with the idea of energy storage - storing excess wind power for dispatching during wind lulls. This allows the transformation of intermittency into a more consistent, constant load.

The cheapest form of storage is compressed air energy; the advantage of the amount of storage offsets the capacity cost making it the most economical method of compressed air energy storage system. The process is to compress the air and store air underground until needed. Some natural gas is necessary to heat the compressed air. Round-trip electrical efficiency is about 80%. There will be some carbon dioxide output (78gC). Now instead of being limited to one-third of the energy being supplied by wind you go to 82%. Carbon emissions, although present, are cut in half (lowest compared to all sources such as wind energy plus intermittent offset and pulverized coal) and could potentially be reduced even more. This is not an inexpensive technology; however, cost of natural gas can increase as sources are reduced. On top of this fuel cost, there can be a carbon tax. If cost of fuel or carbon tax increases, the slope of combined cycle gas turban gets very high – gas turbans are no longer a cheap way of obtaining energy – however although there is a cost premium for wind/CCGT (Combined Cycle Gas Turbines) that would eventually become a cheaper source of energy. Choice of options, CCGT, wind/CCGT, wind/CAES (Compressed Air Energy Storage) is also influenced by resource-distance. Factors which make wind/CAES better than wind/CCGT: long transmission distances, high fuel and/or carbon prices, reductions in CAES capital cost, reductions in capital charge rate, intermediate and/or peaking operation (higher cost of electricity – higher revenues).

Is storage inevitable? No. If the wind farm is distributed over wide geographic area it may reduce the need for a storage area. There are a number of technologies that may store energy without carbon dioxide emissions: biomass-derived gas for CAES; store the heat from compression and use that to reheat the stored air.

Eastern United States wind sources: Class 4 and above wind resources exist off the eastern seaboard. This excites the offshore developers. Even taking into effect the depth of water, there is a large wind resource available along the coast. The gross resource: 400gw (excluding 50% of the area due to wildlife activities). Although wind carries hidden costs (backup generation, storage, and carbon dioxide emissions) the climate-sensitive market will force the issue making wind energy a hard alternative to pass up.

Jette Kjaer
Project Engineer
Elsam Engineering

Denmark legislation demands baseline studies of the environmental impact assessment one-to-two years before construction, during construction, and monitor programs two-to-three years post construction. Two sites have been identified: Horns Reef and Nysted.

At Horns Reef, turbines (with helipad access for monitoring) project 20 meters into the seabed. The ramming of the turbines into the seabed does create noise, which has been studied. The Nysted wind farm is a gravitation foundation because of the clay below the sand. The program for both sites includes monitoring birds, mammals, fish, bottom flora and fauna as well as noise and hydrography, porpoises, sand eels, etc. Much of the focus has been on birds due to the number of migrants in the area.

Bird monitoring considered disturbance impacts (wintering species/resting species) as well as collision risk (transit and local movements). Standard methods were used to monitor birds (radar, visual observations, thermal animal detection systems and aerial surveys). Birds studied tended to avoid not just the wind farm, but the area around the wind farm. Reverse migration has not occurred as a result of the operation of the wind farm. Results suggest that there are fewer members of some species in the wind farm area while other species are more or less the same, still other species appear to “like” the wind farm area. Fewer birds are flying into the wind farm area during operation as compared to the construction phase. Generally, both sites were characterized by local feeding densities of birds, so major effects on bird distributions were never expected. Ducks were displaced and attraction (gulls) occurred. It is too soon to assess the full impacts of displacement. Baseline was not completed on hard substrate habitat (bottom flora and fauna). However studies have since been completed on species taxonomy. Large spatial and temporal variation between species and communities exist. It is expected that the community structure will evolve successively toward a stable composition in the nest five-to-six years.

Seals that were disturbed during installation had been relocated. Continuing monitoring considers influences of turbines on seal ecology and behavior. There is high transit activity over Horns Reef with less foraging in the wind farm area, resulting in no major impacts during the operation phase of the wind farm. Porpoise activity in the construction phase dropped during direct human activity but returned several hours later.

Finally, impacts to tourism were of concern, but apparently this is not an issue. Individuals close to the wind farm have mostly accepted it, while tourists actually come to see the wind farm.

Dr. David Mizrahi
Vice President Research and Monitoring
New Jersey Audubon Society

How can we assess the impact to wildlife? *What must be considered*? There are aquatic resources and aerial biota – focus on avian. The potential for conflict occurs in areas with profitable wind resources that overlap with areas used by birds and bats. In addition to understanding where the wind resource is, we must consider flight paths, nesting, foraging and roosting locations and stopover habits. In addition to these spatial conflicts we must consider temporal impacts such as seasonal and diel activities. Many of our greatest concern are nocturnal animals – due to reduced visibility.

Wind farms constructed in shared areas have had documented adverse effects on birds and bats due to collision mortality, behavioral modifications and the direct to facility construction/indirect (precluding use of former habitat) impacts due to loss of habitat. The risk assessment process must include problem formulation and the effects and exposure (what portion of the population is exposed to the effect?) on the characterized risk. Once the risk is characterized it may be evaluated and either more data may need to be collected, or a management decision can be made.

The primary way to a solution for the potential conflict is to identify the spatial and temporal overlap between wind resource and aerial biota. This needs to be a proactive activity. The evaluation can occur at multiple scales: regional (e.g. Atlantic Flyway, mid-Atlantic States); landscape (e.g. Appalachian Ridge and Valley); and local scale (where the proposed wind project would be.) In areas of overlap we must determine the level of exposure and the effect of aerial biota – these may vary with a variety of things (e.g. season, time of day, weather conditions, species specific movements, topography, turbine design, configuration of the wind farm). After this, we may build an exposure and effect model that considers movement density rates, flight velocity and direction, species composition, mortality collision rates. These attributes must be incorporated into the anticipated outcome.

Some of the issues that can modify the outcome of the model include weather conditions, lighting, time of day, time of year and tidal cycle. The tools that we have at our disposal to evaluate risk include: large scale Doppler radar, marine radar, thermal imaging, and bird behavior. With a network of 150 stations in the continental United States, Doppler radar can identify major migration events and their spatial temporal extent. This provides an important large-scale view of what is occurring. Most of the migration activities are occurring through the eastern US. Already we have some sense that there may be potential conflict with wind energy. Data from individual stations can provide information on a more localized scale further identifying where potential conflict might occur. Not only do we have a "visual" of migratory movements, but also identification of important stopover areas, as well as velocity and direction of movement.

The problem, however, is that there are gaps in coverage of bird-migration data (spatial extent limited to 60 nm) and explicit data on altitude of flights is unavailable, and so the data cannot be used to estimate the local risk at a wind farm. But it is a good "first cut" information. Marine radar, another tool utilized, provides benefits in that it can be mobile and is a powerful tool to look at patterns of flight, density of movement and can be used to evaluate risk (i.e. spatial and temporal) at project scales (hence a valuable tool). Data may be recorded in the vertical and horizontal mode; the cost is $50K for a system. The result is a comprehensive view of migratory behavior. An important consideration however, is that the radar technology cannot make distinctions between birds/bats or species of birds/bats. This is important to consider in as much as bats can be at greater risk than birds (in West Virginia there is a 50:4 bat to bird kill rate in a single fall season).

Accordingly, the design or operation modifications to resolve bat conflicts may be different that those for birds. One way to distinguish between birds/bats is thermal imaging (although this can be expensive) – this might allow an understanding of animal movement through the area. Acoustic detection is a method that would allow for identification of species (however one draw back is that not all birds call and species-specific call rates are unknown). Methods must be combined to assess mortality. Systematic area searches can help determine mortality rates.

Ultimately a model could be developed to estimate the exposure. This would take into account a variety of things including assessment of seasonal effects. The model could be used to assess the future risk. Finally, we need nationwide standards. Mortality at wind farms is inevitable – although the level is unknown – we must decide what is acceptable. Given the scale of proposed wind power development, how do we evaluate the impact of mortality at a single facility? Is mortality the only thing considered? What about habitat loss and degradation?

Dr. Michael Oppenheimer
Professor of Geosciences and International Affairs
Princeton University

Issue: fossil fuels are an environmental problem. The problems are complex and linked together in many ways. Coal, oil and combustion ultimately produce ozone problems, acid rain and fine particles that affect ecosystem, human health and global warming. In addition to air issues there are issues of oil spills, refinery problems, etc. The effects of fossil fuels impact our "view" (smog) and can be fatal (heart attacks). Air pollution travels far distances, making apparent local air pollution have far reaching effects. The biggest problem is global warming.

Greenhouse gases are accumulating; carbon dioxide is as high as it has been in the last 20 million years and if the current trend continues, carbon dioxide is expected to reach its highest in 50 million years, during this century. While there is natural variation in carbon dioxide and temperature (which are highly correlated), the amount of temperature change over time is consistent with the change in the greenhouse effect. Since carbon dioxide is up, temperatures would be expected to also increase, and this has in fact, been found to be true. Temperatures are higher at sea and on land, underground and aloft. Ice-covered areas are receding, glaciers, snow and ice-lines are retreating. Freeze season is shorter for lakes and streams. Heat and humidity are increasing and there are more days of high temperatures. All these trends are consistent with the projection of climate models. Changes may be due to natural phenomenon but, by and large, scientists agree that the largest influence is greenhouse effect. Consequences are becoming apparent to individuals.

The heat wave of 2003 resulted in a peak in the death rate for Europe. This will become more commonplace if heat trends continue. Tropical diseases are likely to increase in some areas. Malaria-bearing parasites bite more frequently in hot weather. While some areas, such as the US, might be able to deal with this, other areas may be at risk. Sea level is rising based on satellite altimetry. Rising sea levels can negatively impact areas such as Bangladesh. What happens to these populations? Major coastal storms, tornadoes and the like have produced no visible trends in frequency or wind speed as yet.

There is a lot of uncertainty in the future degree of warming – we don't know what we will get, but what we do know that the climate change will be greater than anything we have previously dealt with and this can have serious implications. High temperatures will negatively impact coral reefs, placing these ecosystems at high risk. Many species are at risk of extinction due to impacts of global warming.

Closing: worst is yet to come - for instance, if the Greenland ice sheet goes, Florida will be reduced – Miami and southern Florida will disappear. This won't happen right away, and may be centuries or longer off, but it is in the future if warming is not curtailed. The process is under way, perhaps not irreversibly, but a great deal of land could be lost. In closing – some losses are inevitable due to global warming, but solutions are available giving us a good chance to avoid the worst outcomes. Time is not, however, on our side.