EXPANDING WIND POWER IN VERMONT: SITING NEW TURBINES

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As part of its energy policy, Vermont has clearly articulated the three related energy goals of reducing the environmental impacts of energy use, minimizing supply risks and price volatility, and maintaining affordable prices. Developing additional sources of wind energy is a key strategy for achieving these goals. In fact, developing the full potential of wind resources in the state holds great promise for helping to meet the state's energy needs. As of 2003, Vermont consumed over 5.5 million megawatt-hours of electricity per year.[1] The U.S. Department of Energy estimates that 3 percent of Vermont's land area (177,600 acres)[2] may be suitable for wind energy development.[3] If all of Vermont's wind energy potential is developed, estimates for the amount power that will be produced each year range from 5.0 million megawatt-hours (Department of Energy) to 6.0 million megawatt-hours (American Wind Energy Association).[3] This report discusses many of the common concerns specifically associated with the *siting* of wind turbines in Vermont, such as noise, aesthetic, and environmental impacts, and examines policies that other states employ to address these concerns. For a broader discussion of wind energy, see the University of Vermont Legislative Research Shop's report entitled "Wind Power."[4]

IDENTIFYING AND EVALUATING POTENTIAL SITES

Topography, Wind Availability, and Current Projects

The best sites for wind energy development in Vermont are found on north-south running ridgelines.[5] Optimal sites are characterized by elevations between 2500 and 3500 feet with no extended or abrupt changes in the grade of the ridgeline for at least one mile.[5] These locations are considered ideal for the construction of new generation facilities because they frequently exhibit "Class 4" wind speeds[5] (15.7 mph at 50 feet[6]), or above. In Vermont, many of these sites are located in the Green Mountains.[7] Given siting concerns regarding noise production, aesthetic impacts, and environmental consequences, careful consideration is often given to these issues when assessing potential sites for the placement of new turbines.

Currently, there are five proposed wind energy projects in Vermont (see Figure 1), including expansion of the Searsburg wind farm in the southern part of the state. The other projects include placing five turbines on Little Mount Equinox in Manchester, four turbines on an old U.S. Air Force radar base in East Haven, up to 27 wind turbines on Glebe Mountain in Londonderry, and between 12 and 26 turbines on Lowell Mountain in Orleans County.[8]

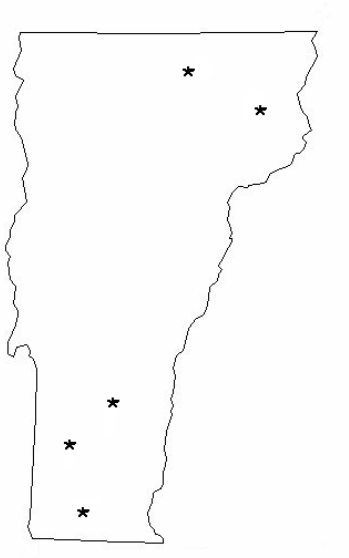

Figure 1. Location of proposed wind energy projects in Vermont.

Viability of Wind Development on Public Land in Vermont

Wind power can be developed on privately or publicly owned land. Of the 3 percent of Vermont's land area that may be physically suitable for wind power development, approximately one third is publicly owned[6] (Table 1).

Table 1. Vermont public land area with potential for wind power development (Source: Vermont Environmental Research Associates 2003).

Wind Class	Speed (mph)	Land area (% of VT)	Federal*	State*	Municipal*
4	15.70	1.20	6.85	13.70	0.00
5	16.60	1.20	6.85	3.42	0.14
6	18.30	0.50	1.37	0.34	0.00
7	24.70	0.002	0.00	0.00	0.00
	Total:	2.90%	15.07%**	17.47%**	0.14%**

*Percentage of land area with potential for wind power development that is federally, state, or municipally owned.
**Percentage of land area within Vermont suitable for wind development.

Virtually all of the state-controlled public land in Vermont is under the jurisdiction of the Vermont Agency of Natural Resources (ANR), which recently announced that under current policy it will not allow large-scale renewable energy development (i.e. commercial wind farms) on ANR lands.[9] In total, ANR lands encompass approximately 20 percent of the potential sites for wind energy development.[10] However, wind energy development in the U.S. has generally occurred on privately owned lands. About 2 percent of Vermont's total land area is both privately owned and physically suitable for wind energy development.[6]

Evaluating Sites

There are several factors to consider when determining whether to construct wind turbines on a particular site:

- Physical accessibility via access roads
- Proximity to an existing utility grid

> Amount and type of infrastructure needed

- Environmental impacts, such as habitat fragmentation and decreased habitat area
- Noise impacts on surrounding communities
- Aesthetic impacts on residents and tourists

These factors represent a balance among optimizing power production, ensuring cost effectiveness, and minimizing the potential visual, aural, and environmental impacts. These impacts may occur during the installation phase or from the ensuing operation of the full complement of facilities needed to produce suitable energy.

The cost-effectiveness of wind energy development depends on the strength and consistency of winds as well as the site's physical accessibility. Ridgelines in the Green Mountains offer the highest and most consistent wind energy generation potential.[11] However, because these mid to high elevation ridges are largely undeveloped, with the exception of commercial ski areas and mountain top communication facilities,[12] these areas are highly valued by residents and tourists for their value as wilderness and for their scenic views.[11] The low degree of development in many of these areas also makes them difficult to access without constructing new roads.[12]

Installing wind turbines requires physical access for equipment and machinery via existing or new roads.[5] Moreover, the operation of wind turbines for energy consumption requires connection to the utility grid. This involves constructing transmission lines to transfer power from the turbines to a substation.[5] These activities can decrease available habitat and increase habitat fragmentation that may negatively affect some species of Vermont wildlife, such as Bicknell's Thrush, moose, black bear, and bobcats.[12] Turbine operation can also lead to direct wildlife mortality, especially for birds and bats.[12]

There are also concerns about the aesthetic and noise impacts on surrounding landowners and communities. One potential conflict involves Vermont's scenic trails and the impact wind turbines might have on tourists, especially along the Long and Appalachian Trails. Scenic views and relatively large undeveloped landscapes are among the expectations hikers have when using these trails.[11] Wind turbines on ridgelines will be highly visible and may affect the viewshed of surrounding areas. Furthermore, there are concerns regarding safety issues that may limit the people's access to proximate areas, as wind turbines can throw damaging ice chunks distances of up to 820 feet.[12]

Searsburg

Vermont's only existing large-scale utility wind energy development is located in Searsburg.[13] Installed in 1997[13], Searsburg's eleven 198-foot tall turbines[14] generate approximately 14 million kilowatts of electricity per year[8] to supply energy to over 2,000 homes.[13] Prior to the construction of the facility, there was concern from local community members over the aesthetic impacts and noise generated by these wind turbines.[15] However, post-construction studies of the Searsburg development suggest that public acceptance of the project has increased since the project was completed.[11]

While aesthetic concerns no longer appear to be a major issue in the Searsburg case, newer wind turbines may be taller than the turbines at Searsburg, which may lead to new aesthetic issues. Newly developed turbines are 330-feet tall,[14] which means that they are more visible from surrounding areas. However, the energy generated from wind turbines increases with height, as wind speed increases with altitude.[16] Hence, the newer 330-foot turbines generate two to three times more power than the 198-foot turbines currently in use at Searsburg.[17] Thus, despite the fact that the newer turbines would likely be more visible to surrounding areas, fewer 330-foot turbines would be needed to generate the same amount of power. Currently, it is unclear what size turbines might be built in the future. Taller turbines are more visible and fall under Federal Aviation Administration laws requiring the installation of aircraft warning lights for all structures over 200 feet tall,[17] which in turn makes turbines even more visible from surrounding areas.

OTHER STATES AND POLICY OPTIONS FOR ADDRESSING COMMON CONCERNS

Wind energy projects typically elicit concerns about noise, aesthetics, and detrimental consequences to specific wildlife species. Many states have developed guidelines and recommendations to address these concerns, often by attempting to minimize the impacts. Local noise ordinances or state guidelines may specifically limit the permissible noise from a wind project. Likewise, there are a variety of turbine designs that may or may not be aesthetically pleasing in particular settings, and guidelines in many places recommend that developers consider the visual impact of wind energy projects, especially in scenic areas. Wind projects affect wildlife through direct kills of birds and bats and indirectly through habitat loss. Hence guidelines exist for turbine designs that are less attractive to birds and bats and to encourage development in areas of poor quality habitat.

Noise

The noise produced by wind turbines is a concern to some neighbors and in some communities adjacent to existing projects. While the degree to which turbine noise is bothersome differs from individual to individual, it is possible to compare the noise levels for a range of common activities (Table 2).

Table 2. Noise level for common activities (Source: The Scottish Office, Environment Department 1994).

Source/Activity	Indicative Noise Level (dBA)
Threshold of hearing	0
Rural nighttime background	20-40
Quiet bedroom	35
Wind farm at 350m	35-45
Car at 40mph at 100m	55
Busy general office	60
Pneumatic drill at 7m	95
Jet aircraft at 250m	105
Threshold of pain	140

Compared to these common activities, at a distance of 750 to 1,000 feet an operational wind farm produces noise similar to that of a kitchen refrigerator in a moderately quiet room. Many methods can be adopted to reduce this noise. For example, more aerodynamic tower designs reduce the noise that is created by wind passing the turbine, and soundproofing and mounting equipment on sound-dampening buffer pads reduces mechanical noise produced by the generator, gears and other moving parts in the turbines. Wind turbine blades are constantly being redesigned to make them more efficient and to reduce the noise they generate. Across the country, states deal with these issues in a number of ways.

Oregon -Oregon requires that wind energy facilities comply with established state standards for noise emissions, as determined by the Oregon Environmental Quality Commission. A wind energy facility must satisfy two tests: 1) the "Table 8 test" and 2) the "ambient degradation test." The "Table 8 test" sets the maximum permissible turbine noise level during different periods of the day (Table 3). The "ambient degradation test" sets the maximum permissible ambient noise level increment to be 10dBA per hour in comparison to noise level during the previous hour.[18] In 2003, the Oregon Department of Energy proposed amendments loosening certain rules.[19] To demonstrate compliance with the noise rules, the developer of a wind energy facility must provide noise measurement data under very specific wind conditions. "It is impossible to predict when those conditions will occur, and therefore impossible to know when to send noise consultants out to the field to collect noise data." [19] Thus, data collection for the purpose of demonstrating compliance with the rule is complicated and expensive.

Table 3. Statistical Noise Limits for Industrial and Commercial Sources. (Source: Oregon Department of Energy 2003).

	Maximum Permissible Statistical Noise Levels (dBA)	
Statistical Descriptor*	**Daytime (7:00AM – 10:00PM)**	**Nighttime (10:00PM-7:00AM)**
L_{50}	55	50
L_{10}	60	55
L_1	75	60

*Defined as the noise level equaled or exceeding 50%, 10% and 1% of the hour, respectively.

Kansas - Concerns about noise are determined based on distances from potentially conflicting uses. The Kansas Environmental and Siting Committee and the Kansas Renewable Energy Working Group provide guidelines for wind power stakeholders to consider potential problems that could be generated in residential areas and the possibility of adopting sound reduction technology. The Noise Management Guidelines include:

- Prospective sites should be evaluated according to the adequacy of setbacks from residential areas and rural homes. Special attention is given to residential units that may be in relatively less windy or quieter locations. These guidelines specifically recognize that existing residents who support the wind system may some day be replaced by others who will object to the noise.
- In cases where acoustic levels are critical because of nearby residences and/or natural surroundings, the wind power project stakeholders are supposed to examine possibilities for using sound reduction technology on appropriate turbines.[20]

Wisconsin - Wisconsin's model ordinance establishes a flat threshold of 50 dBA, measured at residences, schools, hospitals, churches and public libraries and requires that the developer place turbines far enough from these points of measurement to keep noise level at or below the permitted level. This 50dBA threshold is a standard used by most similar ordinances and laws around the country. Local officials in Wisconsin are authorized to consider and, where there are unique characteristics within their communities, set different levels. For example, "some officials prefer that the noise measurements be taken at the property line of neighbors rather than at the structure." [21]

Table 4. Summary of state regulations to address noise impacts of wind energy projects

Noise Regulations and Recommended Actions	**OR**	**KS**	**WI**	**NJ**
Set maximum permissible noise levels for turbine noise	✓		✓	
Set maximum permissible ambient noise level increment	✓			
Consider adequate setbacks from residential areas and rural homes		✓	✓	
Recognize the wind system may be objected by future residents		✓		
Examine possibilities for using sound reduction technology		✓		

Aesthetics

Despite the fact that aesthetics are often individual-specific and sometimes an emotionally charged issue, it is possible to develop some guidelines for turbine design (Table 5). Variables such as turbine height, illumination of each turbine, coloring, symbols the owner places on the turbines and facilities, spacing and placement, affect a project's impact on visual resources. For example, taller turbines, which are usually more cost-effective, are also visible from a longer distance, while

smaller and shorter turbines, which are less cost-effective, tend to rotate faster and are often placed closer to one another and in larger numbers. Access roads to and from wind farms, particularly within mountainous and moorland areas, have a significant aesthetic impact,[22] but this impact could be lessened on relatively flat terrains.[21]

Aversion to towers by citizens in local communities, as well as local planning or zoning boards, is common. Some counties consider towers a "special use," and require a time consuming and expensive permitting process. Local regulations may limit tower height and location for aesthetic reasons. This may include blocking or changing a historic landscape or blocking a neighbor's view. The American Wind Energy Association has recommended hub height at 90 feet for efficient operation.[22] Local regulations, however, may not allow towers to be this high to minimize the potential for blocking views. For example, the New Jersey ordinance requires the maximum tower height to be 75 feet for aesthetic reasons. Local regulations can set their own tower heights to reduce aesthetic impact while maintaining turbine efficiency.

Oregon - The Energy Facility Siting Council, the authority issuing site certificates to developers of large energy facilities in Oregon, does not attempt to reconcile conflicting opinions about the general visual impacts of a specific facility. Instead, existing standards focus narrowly on evaluating the "scenic and aesthetic values identified as significant or important in applicable federal land management plans or in local land use plans" for the analysis area. As part of this evaluation, the Siting Council must answer two questions: 1) Have the applicable land use plans identified any "significant or important" scenic values? 2) Would the visual features of the facility be likely to result in "significant adverse impact" to those values? If the council determines there is a significant impact, the applicant is required to mitigate the impact through implementation of corresponding design measures or by relocating the relevant parts of the proposed facility. [23]

Kansas -The Kansas Environmental and Siting Committee and the Kansas Renewable Energy Working Group have developed a set of guidelines to inform the general public about a project's potential impacts, to elicit input from the stakeholders about these impacts, and to consider adopting various methods to minimize them. These guidelines include:

- Evaluate visual impacts of potential projects by using accurate visual representations of these projects;
- Provide information to landowners, the general public and other key stakeholders regarding the visual impact of wind power projects;
- "Listen to communities and stakeholders in all project phases"; [21]
- Consider adapting the project design to minimize visual expose from visual sensitive areas;
- Evaluate the possibility of and weigh the benefits of using road-less project designs or designs that rely on existing roads; and
- Identify designated scenic byways and popular vistas, and avoid sites that are readily visible from those points. [20]

Wisconsin – Under Wisconsin state law municipalities are prohibited from placing additional requirements on wind project developers based solely on aesthetic reasons. State law explicitly states that "[p]reserving the aesthetic character of the town or similar language should not appear as an explicit purpose of an ordinance or use permit." At the same time, the state assumes that requiring

neutral paint and limiting lighting and signage can address most visual issues. Project developers see this approach as a way of addressing aesthetic concerns while reducing impacts.[21]

Table 5. Summary of state regulations to address aesthetic impacts of wind energy projects

Aesthetic Impact Regulations	**OR**	**KS**	**WI**	**NJ**
Evaluate visual impacts	✓	✓		
Consider implementing corresponding design measures	✓	✓	✓	
Relocate the relevant parts of the proposed facility	✓			
Provide information to landowner and the public		✓		
Consider road-less project designs		✓		
Avoid sites visible from scenic byways and popular vistas		✓		
Limit the maximum height of a turbine				✓

Habitat and Wildlife Impacts

Wind turbines affect wildlife populations through direct mortality, behavioral modification, habitat fragmentation and habitat reduction. Specifically, turbine blades may kill birds and bats or may cause them to alter flight paths. Nationwide, an estimated 100 million to over 1 billion birds are killed each year in collisions with man-made structures, but less than 1% of this mortality results from collisions with wind turbines (Table 6).[24] Most studies on bird and bat mortality from collisions with wind turbines have been conducted in western and Midwest states at wind energy projects in open areas such as grasslands and livestock grazing areas.

Table 6. Estimated annual avian mortality in the U.S. from collisions with man-made structures (Source: National Wind Coordinating Committee 2001).[24]

Collision Source	**Estimated Annual Bird Mortality**
Vehicles	60 – 80 million
Buildings (including windows)	98 – 980 million
Power lines	Tens of thousands – 174 million
Communication towers	4 – 50 million
Wind turbines	10,000 – 40,000

These data translate to a range of less than 1 to 7.5 bird deaths/turbine/year,[25,26,27,28] with most mortalities coming from common resident species and raptor mortality being "virtually non-existent"[27] despite active raptor nests within several miles of study sites. Several other studies confirm that bird mortality from wind turbines is similar in magnitude to mortality from other man-made structures.[29,30] However, there have been few studies on New England species, because the wind energy market in this region is relatively new and because much of the concern over avian mortality from wind turbines stems from the large number of bird kills at the Altamont Pass Wind Resource Area in California.[31] Flight patterns of East Coast bird species suggest that turbines located along ridge tops may pose a greater threat to birds than turbines in valleys or plains,[25] despite the generally low avian mortality rate from collisions with turbines.

Estimates for bat mortality range from less than 1 to 47.5 deaths/turbine/year,[25,26,27,28] with most estimates at the lower end of this range. Bat mortality is less well studied than bird mortality, but Bat Conservation International recently conducted a three-year study, for which the results have yet to be published, to better understand the issue.[25]

There are fewer studies on how wind turbines affect bird behavior. Some results suggest that the effects on flight paths are minimal.[32] A study of geese in Denmark found a smaller avoidance distance for turbines arranged in lines or near already disturbed land compared to turbines arranged in clusters.[33]

Wind turbines and turbine construction can lead to habitat fragmentation and reduction. Using existing roads for construction and building wind farms in areas of poor quality habitat, such as agricultural areas, can minimize this impact.[25]

Several states have guidelines for minimizing wind energy's negative impacts on birds and bats that are similar to those proposed by The American Bird Conservancy (ABC)[25] (Table 7). These guidelines include conducting preliminary studies, avoiding migration routes and nesting areas, building near already disturbed areas, avoiding construction styles that encourage perching or are difficult for birds and bats to see (guy wires, lattice work, above-ground transmission lines), and minimizing the use of aircraft warning lights that attract birds. The ABC recommends special consideration for areas that might contain endangered or threatened species.[25]

Washington - The Washington Department of Fish and Wildlife (WDFW) guidelines for siting and developing wind power projects consist of a recommended pre-project assessment and a habitat mitigation process.[34] The preliminary assessment includes a review of existing information regarding local species and habitats, habitat mapping, and biological surveys (of raptor nests, avian use, and threatened and endangered species). The Wind Power Guidelines include recommendations to minimize impact on the environment:

- Develop in already disturbed lands using existing roads/transmission corridors;
- Avoid guy wires, lattice towers;
- Use underground power lines;
- Minimize tower lights;
- Control noxious invasive weeds after construction disturbance; and
- Include plans for decommissioning and site restoration program when operations cease.

Additionally, the WDFW suggests that developers set up a Technical Advisory Committee, composed of stakeholders such as state and federal wildlife agencies, the energy company, environmental groups, and local landowners, to monitor data from the project and suggest adjustments.

Washington State's Wind Power Guidelines specify that "[p]roject developers are responsible for acquiring [and managing] replacement habitat" for lands that are permanently or temporarily degraded from wind power projects. The guidelines include specific instructions for mitigation, which is required except for projects located in areas of "little or no habitat value",[34] such as land that is being cultivated, under long-term development, or disturbed by a road.

Kansas -The Kansas Renewable Energy Working Group (KREWG) issued wind power project guidelines[20] covering nine total subject areas. Of these, three address environmental concerns (Land Use, Natural and Biological Resources, and Soil Erosion and Water Quality). In terms of Land Use, KREWG recommends that wind energy developers consider local compatibility issues and regulations, promote turbines on already developed land, and give special consideration to areas with rare, endemic habitat. The guidelines for Natural and Biological Resources closely follow recommendations from the American Bird Conservancy that are designed to minimize impacts on birds and other wildlife:

- Conduct preliminary studies of the prospective site;
- Work with wildlife agencies, university groups, environmental groups;
- Review wildlife habitats, migration corridors, breeding areas;
- Give special consideration to threatened/endangered species;
- Avoid large areas of native vegetation;
- Use below-ground power lines;
- Disallow perches or lattice construction on turbines;
- Minimize warning lights;
- When it is "impossible to avoid significant ecological damage" consider mitigation such as restoration or easements; and
- Consider a broader scale of cumulative impact from multiple regional wind projects.

Soil Erosion and Water Quality guidelines are generic and apply to any major construction project in less well-developed areas. These guidelines suggest that construction take place on flat ground, during seasons when the ground is less susceptible to erosion (i.e. frozen or dry soil), and that preexisting roads be used where possible.

Wisconsin - Wisconsin defers to federal regulations, such as The Endangered Species Act and the Migratory Bird Treaty Act, to address the issue of bird kills on wind farms. Wisconsin has developed a model ordinance regarding wind power development for communities throughout the state. This model ordinance requires that project developers comply with all federal and state laws.[21]

Oregon - The Oregon Department of Energy, Energy Facility Siting Council requires that the design, construction, operation, and decommissioning of wind power projects take place in accordance with all state laws regarding protected plant and animal species.[35] State administrative rules state that wind power development is prohibited in federally and state designated protected areas, such as national parks, state parks, wilderness areas, wildlife areas, and recreation and scenic areas.

Minnesota - The State Environmental Quality Board (EQB) issues permits for wind energy projects that are designed in a "manner compatible with environmental preservation, sustainable development, and the efficient use of resources." Permit applications must address potential environmental impacts, mitigation activities and unavoidable adverse environmental effects. Before the EQB approved the state's first major wind energy project in 1995, it required a four-year study on how turbines would affect local avian species. A subsequent two-year study on how turbines affect local bat populations was commissioned,[36] though these results are not yet available.

Table 7. Summary of state regulations and recommendations to address habitat and wildlife impacts of wind energy projects

Regulations and Recommended Actions	WA	KS	WI	OR	MN
Conduct preliminary studies	✓	✓			
Location restrictions					
Build in poor quality habitats/already disturbed areas	✓	✓			
Avoid migration routes, nesting areas		✓			
Use existing roads	✓	✓			
Avoid large areas of native vegetation		✓			
Prohibit projects in state/national parks, recreation areas, etc.				✓	
Construction restrictions					
Minimize guy wires	✓				
Minimize lattice work	✓	✓			
Use below-ground transmission lines	✓	✓			
Minimize aircraft warning lights	✓	✓			
Build on flat ground		✓			
Build when soil is frozen/dry		✓			
Special consideration for threatened/endangered species, habitat	✓	✓	✓	✓	✓
Mitigation	✓	✓			✓
Control noxious invasive weeds after construction	✓				
Work with variety of stakeholders	✓	✓			
Defer to federal regulations			✓		

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