

Land-based Wind Energy:

A Guide to Understanding the Issues and Making Informed Decisions



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Produced by CLF Ventures, Inc.

In partnership with the Massachusetts Clean Energy Center

About CLF Ventures:

CLF Ventures has prepared this resource guide in partnership with the Massachusetts Clean Energy Center. CLF Ventures is a non-profit affiliate of Conservation Law Foundation (CLF) that works in collaboration with public and private organizations to advance sustainable innovation and bring about positive environmental change. CLF Ventures does not engage in advocacy activities, but its projects are consistent with the mission of CLF. As such, CLF Ventures supports the development of appropriately sited wind projects that result in environmental and community benefits and supports responsible renewable energy development that results in a thriving New England economy.

A note about citations

Sources used to develop this document are cited throughout the text. Full citations for each source may be found in “References by Section” starting on page 26.



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Introduction

As the world recognizes the need to move beyond fossil fuels and other traditional energy sources, new energy generation technologies raise new issues and considerations for communities, developers, and policy makers at all levels of government. With that in mind, we hope this guide will help decision-makers navigate the complex issues involved in siting one of those technologies: land-based wind energy.

Individual projects will always have to be weighed by their individual merits, and this resource guide is not intended to support any specific project in Massachusetts or elsewhere in New England. It is intended as a tool for decision makers and community members to enhance their understanding of the questions surrounding wind development and to provide resources on how communities can collaboratively evaluate the potential for utility-scale, land-based wind energy. This guide uses the term “utility-scale” to refer to a turbine or group of turbines capable of generating more than one megawatt of electricity.

This guide provides overviews of important wind energy siting issues, including best practices for community engagement and tips on how to navigate the steady stream of complex and often conflicting information about wind energy development. Shared understanding of these topics is especially critical in Massachusetts where we maintain a strong tradition of home rule for governing local activities. The positive aspects of a new clean energy economy will be widely shared among Massachusetts communities, but decisions about individual projects will be largely made through local authority.

Specifically, this guide includes:

- Guidelines for how to assess the quality of information that you find and how to resolve conflicting points.
- Overviews, contextual information, and recommended reading on important topics like wind turbine sound, shadow flicker, health, property values, and energy project economics.
- Recommendations on how to structure a robust local review process when siting wind energy projects. By this we mean a process with full participation by relevant stakeholders, transparent decision-making, and durable outcomes with public support.

This guide provides an overview of the primary reasons to consider wind turbines as part of our changing energy infrastructure and explores some of the questions you may need to address to decide about utility-scale, land-based wind development. It provides the information needed to identify the right questions, find good sources of additional information, and work with your community and technical experts to determine whether and in what form wind energy may be appropriate for your community.

Development projects of any type are accompanied by complex questions and difficult decisions that require weighing costs and benefits. As our energy infrastructure ages and old facilities are replaced with new, we are faced with tough choices about where to site the next generation of energy-producing facilities. Wind-powered turbines are one option for new utility-scale energy generation, and these machines need to be located where the wind blows with sufficient sustained force.

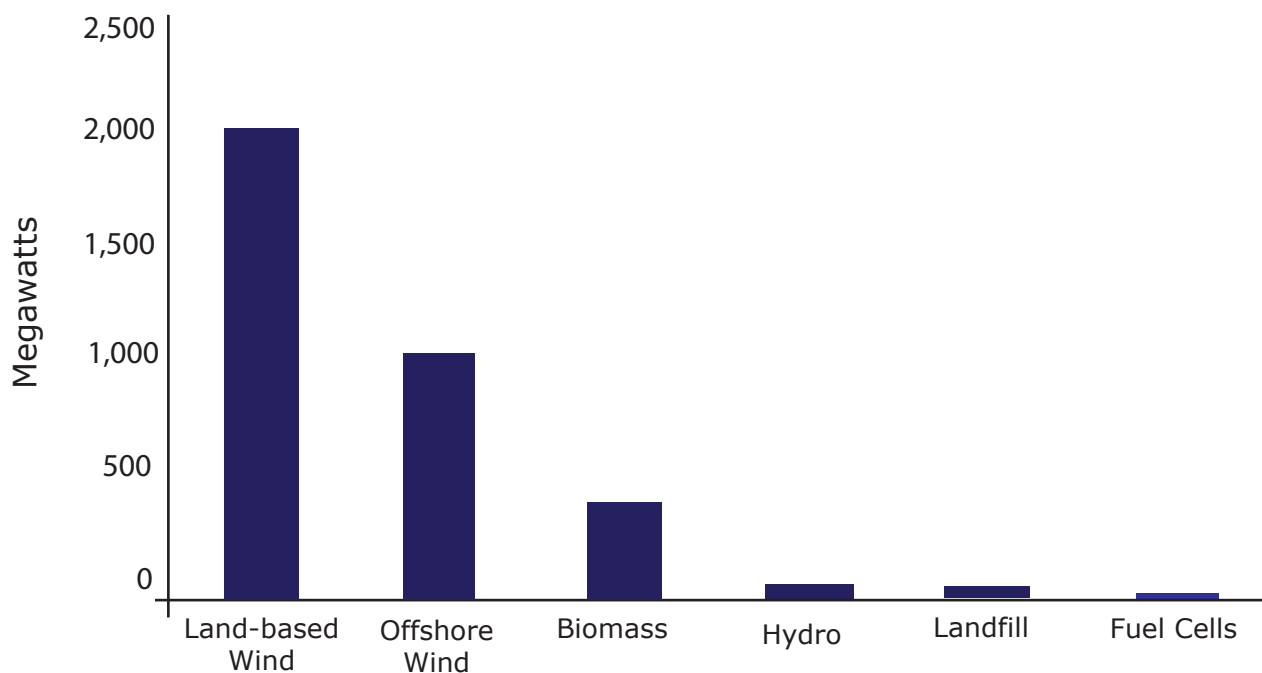
Big cities and small towns, urban residential areas and rural communities are all considering the possibility of constructing or allowing the construction of utility-scale wind turbines. A lot of information is available that describes both the costs and benefits of wind energy, but much of this information is specific to individual projects. Each project will have a unique set of circumstances that must be evaluated and will raise particular questions. Because the answers will be different in each case, depending on a project's specific details and circumstances, this guide does not attempt to provide definitive answers to these difficult questions.

When reviewing the contents of this guide, gathering additional materials, and reviewing information provided by people involved in these

projects, keep in mind the next section, "How to make sense of information about wind energy." Think about what technical information is needed to properly evaluate the potential impacts of wind energy in your community. Additionally, as with any development project, ensure the evaluation process is collaborative and inclusive of as many perspectives and stakeholders as possible.

Ultimately, the information and process guidance contained in this guide can serve as a starting point to help you decide whether a particular wind energy project may be a positive addition to your community.

Renewable Energy in the ISO-NE Interconnection Queue



There are over 2,000 MW of land-based wind already in the ISO-NE interconnection queue. While not all of these projects will be built, this chart demonstrates the volume of interest in wind power in New England, and the need to understand the siting issues in order to make informed decisions.

Source: ISO-NE Regional System Plan 2010

How to make sense of information about wind energy

There are many types and sources of information available to help you make decisions about wind energy. Studies published in “peer-reviewed” journals are subject to formal and independent academic quality control to ensure that they use accurate data and that their conclusions are based on sound evidence and methods. Scientific information published by government agencies is also subject to internal peer review. However, many sources of information related to wind energy are not peer-reviewed; these include reports from non-profit organizations, industry association white papers, and proceedings from academic and professional conferences. Additionally, the Internet and the news media are awash with reports from individuals who have had experiences living near wind turbines.

Some sources of wind energy information are more reliable than others. Some non-peer-reviewed reports and white papers may be highly credible and useful and may be helpful when evaluating these complex topics. Reports of personal experience may be informative, but should be considered in the context of the specific project with which they are associated. Personal experiences of one facility will not necessarily be relevant in the context of another facility, given differences in technologies, locations, and other project-specific variables. In general, for any information source, care should be taken when using project-specific information to evaluate other projects.

We now have relatively easy access to a large amount of many types of information. Here are

some questions to keep in mind when evaluating research and anecdotal reports on wind energy:

- Has the research been peer reviewed? Are the results based on reliable data and methods?
- What are the authors’ credentials? Is the information presented by an individual, organization, or government entity that you know and trust?
- Do the authors have a personal or financial interest in the information they present, and do they disclose that interest?
- Are the conclusions based on documented, factual information from other sources you know and trust?
- How current is the information? For web material, when was it posted and/or last updated?
- Is there broad consensus regarding the information presented, or is it based on the conclusion of one individual or one study?
- How generalizable is the information? Is it specific to a particular project location and project size, or is it more widely applicable? How does it relate to the size, scope, and location of the project you are considering?
- If the information is anecdotal, what are some of the key features that make it comparable to, or distinguish it from, a project you may be considering?
- How representative is the information of the views and experiences of all people who might be affected positively or negatively by a particular project?

Why are Massachusetts and its communities considering wind energy?

Wind is one of the fastest growing sources of electric power generation in Massachusetts and in the United States. As of the date of this publication, Massachusetts has over 90 megawatts (MW) of land-based wind power capacity either online or under construction, and the state has a goal to install 2,000 MW of wind power by 2020. In addition, Massachusetts has a Renewable Portfolio Standard that requires 15% of our electricity to be generated by new renewable sources by that same year. While some of this energy may come from our neighboring New England states and Canada, much of it can be generated in Massachusetts due to the state's available wind resources. Although siting new wind power can be challenging, wind is a renewable, emissions-free, local resource that can diversify Massachusetts' electricity fuel mix and contribute to our state's clean energy future.

Fossil fuel consumption and climate change

Massachusetts is part of a regional power grid where the supply of electricity must be continually balanced against user demand. In order to minimize electricity costs to consumers, the grid operator administers a wholesale electricity market that allows for the purchase of enough electricity to meet anticipated demand. This system allows demand to be met by the most economic generation options – in other words, the cheapest source of electricity. Because there are no fuel costs associated with wind and wind turbines are relatively inexpensive to operate once they are built, when wind power

is generated it will bump out the most expensive options. In New England, wind power typically displaces electricity generated from natural gas, and at higher penetration (i.e. more wind energy) could also displace coal or oil.

Wind power produces no direct emissions of climate-warming greenhouse gases, unlike electricity from natural gas, coal, and oil. The National Renewable Energy Laboratory (2009) estimates that 1,000 MW of wind power capacity can offset the emission of 2.6 million tons of carbon dioxide annually, which is equivalent to the emissions of over 460,000 passenger vehicles or a little more than half of the emissions of a typical coal plant. Claims have been made that wind power does not help mitigate climate change because wind power is intermittent and requires backup power generation. This assertion does not take into consideration that the grid operator can predict wind availability and balance wind's variability by quickly "ramping up" or "backing down" the flow of electricity from existing flexible resources such as natural gas or from demand-side resources that can quickly curtail electricity use.

The electric grid is designed to include redundancy of resources. This measure is in place to ensure reliable electricity, independent of wind or any other type of electricity generation. In other words, the current electricity system already includes redundant resources and spinning reserves, so wind's intermittency is balanced by the reserve capacity of other energy sources across the entire grid as well

as by the ever-increasing capacity of demand-side resources. In Massachusetts and the rest of New England, much of this redundancy takes the form of natural gas plants, which can adjust their energy generation up and down more quickly than coal and oil-fueled power plants. While there may be some minor efficiency loss at the natural gas plant from ramping up and backing down to balance the variable flow of wind power, overall, the decrease in total natural gas burned and decrease in associated CO₂ emissions due to wind power displacing natural gas-generated electricity on the grid is greater than the loss in combustion efficiency (NREL 2010).

Energy security and local economic benefits

Since the overwhelming majority of electricity in Massachusetts is produced by imported fossil and nuclear fuel, increasing the production of wind energy can increase local and regional energy independence by helping to mitigate the risk of supply cutoffs or shortages. New England is relatively far away from all sources of fossil fuel, both international and domestic, so fuel or electricity must be transported over long distances. Over 40% of the electricity in New England is now generated by natural gas, all of which must be transported here from other parts of the US and Canada through pipelines or liquified natural gas (LNG) terminals. Coal plants, using fuel primarily sourced in South America, generate an additional 12%.

Other benefits for cities and towns include municipally-owned wind turbines or private, long-term fixed-price contracts, which can offer a hedge against future fossil-fuel price volatility. Wind production also confers a number of direct economic benefits to host towns and properties through local job creation, municipal tax revenues, and land-lease payments. Additional economic benefits include revenue for local businesses that provide services to wind-power projects and

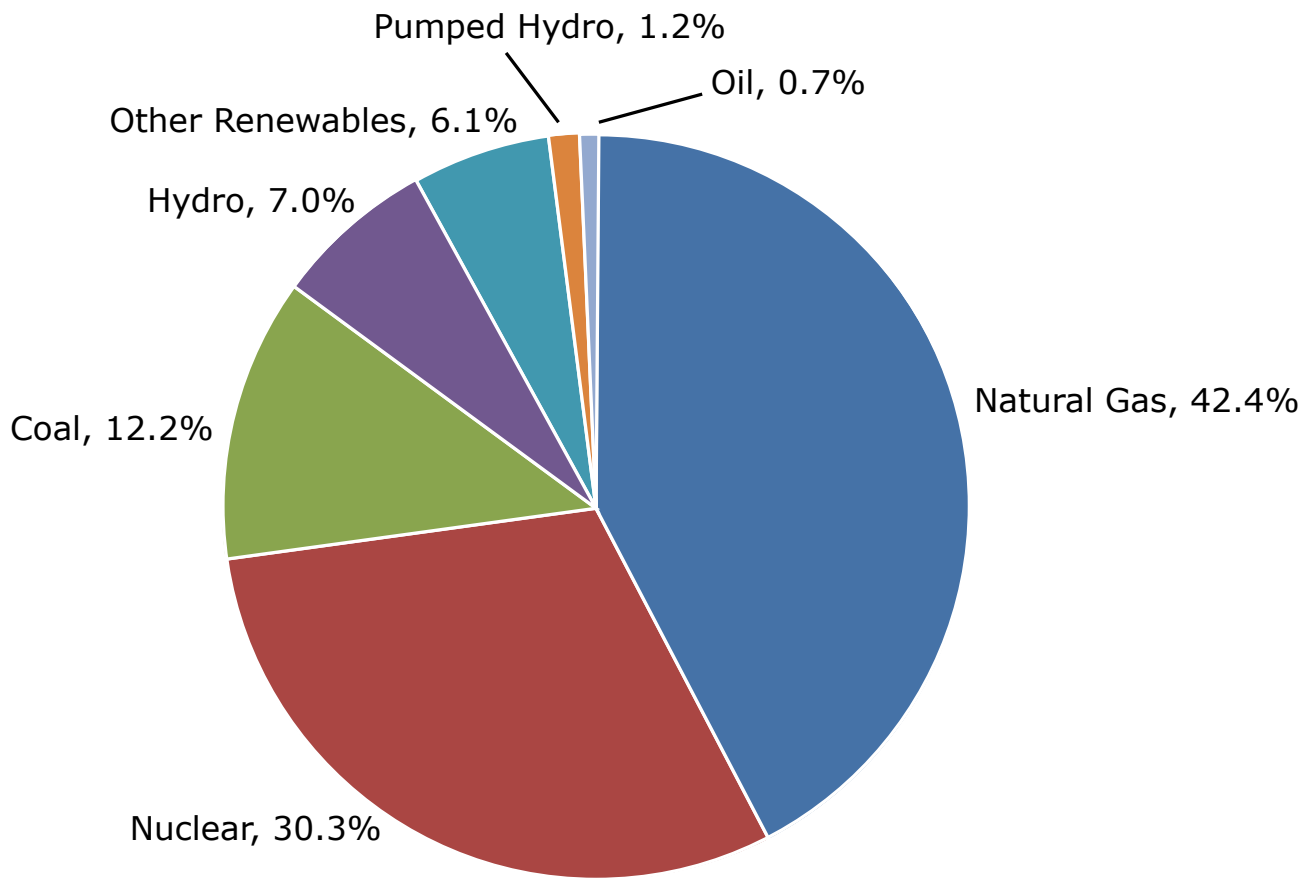
increased local spending on goods and services in surrounding areas.

Natural resources conservation

All forms of energy production affect the environment, but wind power compares favorably to fossil-fuel-based energy and nuclear power across the electricity production lifecycle. As with all energy facilities, construction of wind power components and facilities requires the use of metal and cement, among other materials, with associated environmental impacts. However, wind is an inexhaustible, local resource that avoids destructive impacts—air and water pollution and wastes associated with fuel extraction and disposal—that accompany mining of coal and uranium ore, drilling for natural gas, or disposal of mine tailings or spent nuclear fuel. Natural gas extraction and nuclear and fossil-fuel power generation consume huge volumes of water. In Massachusetts alone, an estimated 1,293 million gallons of water could be conserved annually for each 1,000 MW of wind energy capacity installed (NREL 2009).

Unlike combustion of fossil fuels, especially coal, wind power generation emits no climate-warming greenhouse gases and none of the air pollutants, such as sulfur dioxide, nitrogen oxides, particulate matter, and air toxics, associated with a range of adverse health and environmental impacts, including respiratory and cardiovascular disease, acid rain, and smog. Additionally, mining, processing, transportation, and disposal of fossil and nuclear fuels are extremely land- and energy-intensive. While wind power installations can also require large areas of land, wind turbines are often compatible with existing land uses, such as farming and forestry, and can support and enhance land conservation efforts. Further, wind power projects have a fixed footprint, whereas extractive energy sources impact additional land areas every year.

2009 New England Electricity Generation by Type



New England is highly dependent upon natural gas for electricity, (as well as heat). Together, fossil fuels supply around 55% of New England electricity. Source: ISO-NE Regional System Plan 2010

Economics

Utility-scale wind energy developments are significant, energy-generating infrastructure projects. As with all utility-scale energy facilities, it is expensive to permit, design, and build a project, and the actual power-generating equipment is a large capital expense. Energy facility developers must invest substantial sums at the start of a project and recover those costs over time through the sale of electricity. In addition, power sale revenue must cover the cost of lease payments for land, tax payments, and other economic benefits to the community in which the development is located. Factors such as the strength of the wind resource and cost of land in different locations also impact the economic viability of wind energy facilities, and in New England these factors tend to make the economic margins very tight. There is relatively less land and the locations with good wind can be physically difficult to access.

Local economic benefits

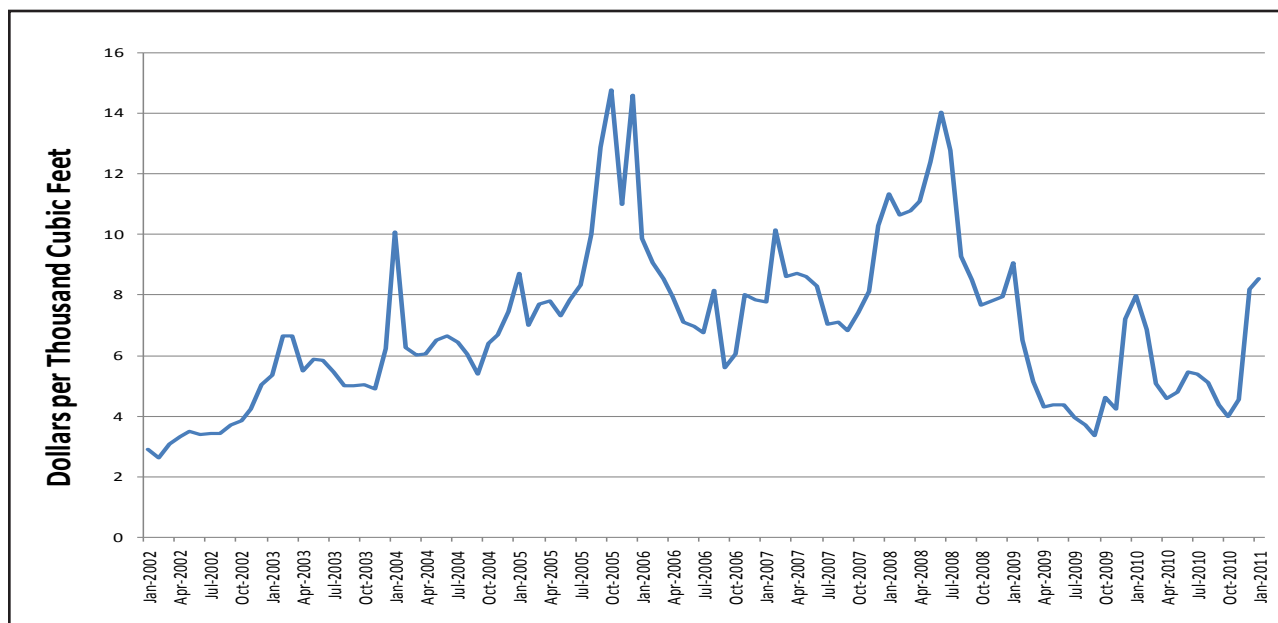
The issue: Utility-scale wind energy developments are significant pieces of infrastructure. They require professional engineering and construction services and, when privately owned by a tax-paying entity, must pay some form of taxes to the communities in which they are located. In addition, since the land on which projects are constructed is often owned by other private parties, developers establish lease payments to the property owners for the right to erect turbines on the property. These agreements provide income to individual landowners for the life of the project.

More information: The construction phase of the project requires significant numbers of construction workers and others engaged in engineering and site work. The local workforce will fill some of these jobs, while others will attract out-of-town workers who will spend money in the local economy. After construction, this economic benefit will diminish, but the ongoing operation of a utility-scale wind development will require some permanent employees (NREL 2005).

One significant benefit of wind is an infusion of additional revenue to the host city or town, which can support municipal services or alleviate pressure on the property tax. The receipt of revenue can happen in one of two ways. A municipality may value and assess the wind power generating facility as it would any other real property, resulting in property taxes paid to the town. Alternatively, the Electric Utility Restructuring Act of 1997 creates a mechanism for municipalities to negotiate voluntary tax agreements (also called payment-in-lieu-of-taxes or PILOT agreements) with energy facilities. The latter option may be preferable for both the developer and the municipality, as it will provide payment/revenue certainty and stability for both parties.

Publicly-owned projects do not provide tax revenue, but the project is owned by the community, which can use the power generated to either offset municipal energy use or sell the power to create revenue. In Massachusetts, wind power generation creates Renewable Energy Certificates (RECs) in addition to electricity. These certificates can be sold separately from the power for additional revenue.

Historical Natural Gas Price Fluctuations



Historically, the price of natural gas has fluctuated dramatically from year to year, which has had significant implications for the price of electricity in New England.

Source: US Energy Information Administration 2011

Private wind energy developers may also create Community Benefit Agreements with local communities. An agreement may include commitments to make additional direct payments but can also include capital improvements and equipment purchases by the developer for the community. Funds have also been used to create grant and loan programs that provide funding to local initiatives. Community Benefit Agreements will differ from community to community since they are based on the particular needs of each community and the financial resources of the project developer.

Electricity prices

The issue: The price of wind energy is stable, but it can be higher or lower than the price of fossil fuel-based energy depending on the variable price of fossil fuels, such as natural gas and coal. When natural gas prices are low, power generated by natural gas will be cheaper, and wind energy will

appear relatively more expensive. However, as shown in the chart above, the price of natural gas has been highly variable over time.

More information: Unlike fossil fuel-based energy, the price of electricity from wind is not affected by the price of fuel. The “fuel” for wind energy is the wind, which does not need to be purchased. Fossil fuel prices are subject to market pressures that make the price of fossil energy fluctuate. This makes wind more or less competitive depending on the price of fossil fuel. As fossil fuels become scarcer, or when the supply of fuel is constrained for any reason, the price of fossil fuel-based electricity can increase dramatically. In other words, the price of electricity from wind, in some cases, may be more costly than current electricity from fossil sources, but this is likely to change in the future (Lawrence Berkeley National Lab 2006).

When a wind power seller and a wind power buyer enter into a long-term contract for electricity, both sides should also consider the possible price of electricity in the future. The seller must sell electricity for a price that allows it to recover its project costs, and the buyer is interested in long-term price stability and predictability, even though current energy prices may be slightly higher.

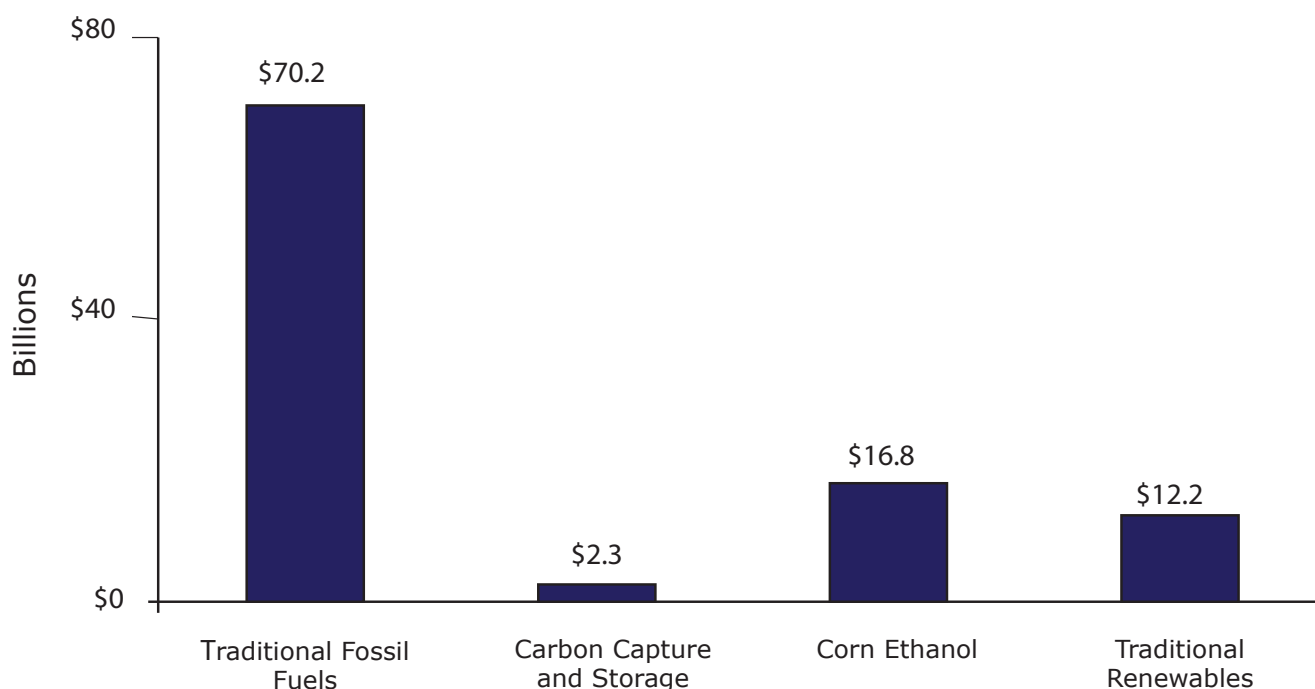
Government subsidies for renewable energy

The issue: All forms of energy generation in the US receive some form of public subsidy, as shown in the chart below. This can be in the form of tax credits or other tax incentives as well as more direct payments (Environmental Law Institute 2009). In addition, many environmental and public

health costs from traditional energy sources are borne by the public rather than by the energy facility owner or operator. These public costs for private benefits are referred to as externalities and can take the form of harmful air emissions or environmental contamination from mining and drilling, among other potential problems that have associated economic costs.

More information: Wind receives direct and indirect subsidies just as any other form of energy generation, but the amount of money accompanying these subsidies is significantly less than the amount provided to fossil energy generation. As indicated below, this includes about \$72 billion total to fossil fuels (between 2002 and 2008), including a relatively small amount to carbon capture and storage, \$17 billion for corn ethanol, and only around \$12 billion for wind and other traditional renewables.

Energy Subsidies: Fossil vs. Renewable



Subsidies to traditional fossil fuels vastly exceed subsidies provided for traditional renewables such as wind and solar. Subsidy amounts represent totals over the course of a seven-year study period

Source: ELI 2009

A significant portion of the fossil fuel subsidies come from two tax breaks, which have been written into US Tax Code (renewable subsidies have not been written into the Tax Code, and are therefore much less permanent). The Foreign Tax Credit provides about \$15 billion in subsidy dollars and the Credit for Production of Nonconventional Fuels provides about \$14 billion (ELI 2009).

There is a difference in the timing of the subsidies available to wind and other renewable energy sources. The economic incentives, such as tax credits and grants, are periodically renewed by the federal government for specific periods of time. In the past these incentives have expired and thus have been unavailable for periods of time. The lack of certainty about the availability of the incentives, which are necessary to the economic viability of capital-intensive projects, hinders their usefulness (ELI 2009). Developer interest in incentives is a matter of practical project economics for companies that are trying to build the next generation of our electrical power supply. However, the sporadic availability of these subsidies has led to increased pressure to secure permits and approvals more rapidly.

Wind turbine efficiency

The issue: There are two ways to talk about electric power efficiency. One is capacity factor, the amount of energy generated over a certain time period compared to what would be generated if the generator is operating at full capacity. The other is conversion efficiency, how much of the energy from a fuel is converted into electrical energy.

More information: With fossil energy, electric energy is generally extracted from the fuel by combusting it and using the resulting energy to turn a turbine that creates electricity. During this process some of the energy in the fuel is

lost in the form of heat and some is lost to the mechanical workings of the power plant. The result is a conversion efficiency of 30% to 50% depending on the fuel and the technology used to create electricity (Tester et al. 2005). For example, 50% of the energy in natural gas may be converted into electricity and 50% is lost (for older coal-fired facilities this is closer to 30% energy conversion and 70% energy loss). With wind energy, the wind turns the turbine and creates electricity. Maximum wind turbine efficiency is recognized to be about 40%, based on the amount of energy it is physically possible to capture from the wind (Tester et al. 2005). In this sense, wind turbines are about as efficient at converting wind into electricity as standard technologies are at converting fossil fuels to electricity.

However, the wind does not blow constantly or at a constant speed. Fossil power plants can operate almost constantly, but must be stopped for periodic maintenance. Some may operate at full capacity for 90% of a given year and so have a capacity factor of 90%. Other fossil power plants may be used intermittently to manage daily changes in electricity demand and so may have much lower capacity factors. Wind turbines operate when the wind blows at sufficient speed, and their output increases as wind speeds increase. As a result, wind turbines have an annual capacity factor that generally ranges from 15% to 30% on land in Massachusetts (MA Office of Energy and Environmental Affairs 2011).

No form of energy is 100% efficient or has a capacity factor of 100%. It is important to consider capacity factor and efficiency because these numbers help predict the amount of electricity a project will generate and the corresponding revenue from the sale of this electricity. But it is equally important to understand these numbers in the context of other forms of energy.

Visual Impacts and Health

Wind turbines elicit a wide range of aesthetic reactions among people who view them. Some people see wind turbines as graceful symbols of a clean energy future while others may find that wind turbines dominate the landscape or lessen the beauty of surrounding areas.

In addition to aesthetics, moving shadows formed by the rotating blades of a wind turbine as the sun passes behind it can cause fluctuations in light intensity, a phenomenon known as “shadow flicker.” Shadow flicker may occur at greater distances when the sun is shining low in the sky – generally around sunrise or sunset – and when a person or object is lined up with the sun, the turbine, and the direction of the wind. Shadow flicker is not a constant phenomenon, but may occur for a limited period of time and in limited locations and circumstances. Many factors determine the intensity, location, and duration of shadow flicker, including latitude and season, weather conditions, landscape features, size and shape of a turbine, and proximity to the turbine. Light glinting off a turbine blade is rarely an issue with modern wind turbines because of the use of low-reflective materials on the blades and towers.

Shadow flicker and health impacts

The issue: Some people living near wind turbines have reported experiencing negative health impacts, such as headaches and dizziness, which they attribute to shadow flicker from the turbines.

More information: As of the date of this publication, no studies in the epidemiology or medical literature have reported that shadow flicker from utility-scale wind turbines is harmful to health. However, some people find shadow flicker annoying, especially if they experience flicker when they are inside their homes (National Collaborating Centre for Environmental Health 2010). It is important to identify potential flicker effects during the design phase of a wind project and employ tools to help mitigate flicker or manage it.

There are no documented cases of epileptic seizures caused by shadow flicker from utility-scale wind turbines, and the risk of such an event

occurring is negligible – less than one in ten million (Environment Protection and Heritage Council 2010). Some people with epilepsy can have seizures triggered by light flashes or flicker between 5 Hz and 30 Hz (flashes per second), but utility-scale wind turbine blades typically rotate at 0.6 Hz to 1.0 Hz, well below the level that could trigger a seizure (National Research Council 2007).

Shadow flicker predictability and mitigation

The issue: People are concerned that they will be affected by shadow flicker in their homes.

More information: The position of the sun relative to a specific location can be easily predicted. Several software programs can provide detailed predictions of the location and timing of potential wind turbine shadows based on turbine location, design, and operating hours; location of residences, occupied buildings, and roadways; and meteorological information, such as wind direction and probability of sunshine for

a given area. Wind energy developers can use this modeling data to reduce potential shadow flicker in the design and siting phases of a wind project. Strategies to manage shadow flicker from existing wind turbines include using plantings or window treatments to reduce the visual impact of shadows or programming brief shutdown periods into turbine controls.

Some states, including Massachusetts, provide guidance to towns and developers about shadow flicker. In Massachusetts, model zoning guidance states that wind turbines “...shall be sited in a manner that minimizes shadowing or flicker impact” (MA EEA 2009). Massachusetts guidance doesn’t set specific limits on maximum acceptable flicker, but 30 hours per year of flicker on residences or occupied buildings has been used as a limit by several states and municipalities (New England Wind Energy Education Project 2011).

In addition to post-construction mitigation, there are tools and processes that communities can use during the siting process to evaluate the potential visual impacts of a proposed wind installation on the surrounding landscape and to help determine the best location for a given project. The software programs described above, together with computer-based site design and engineering tools, can generate optimized project layouts. These designs can then be discussed with local officials and community members and revised to meet on-the-ground needs. This requires close coordination and open communication between the community and project developer, or between the community and its technical consultants if the community is developing a project. It may also be useful to engage a neutral facilitator to guide such discussions.



Wind turbines in Searsburg, VT. Image credit: Searsburg Wind.

Sound and Health

Wind turbines contain mechanical and electrical components that produce sounds that are sometimes heard by people. Design advances have made the mechanical systems relatively quiet, but as wind moves past the rotating turbine blades, sound is created. This aerodynamic sound, often described as a swishing sound, may be heard in areas that surround the turbines. Sound is typically characterized by sound pressure, or loudness, measured in decibels (dB), and by frequency, or pitch, measured in hertz (Hz). Atmospheric conditions, such as air-flow patterns and turbulence, the presence or absence of other nearby sources of sound, the topography of the turbine site, and the location of the listener all affect the creation and perception of wind turbine sound.

Ambient sound levels and decibel limits

The issue: Massachusetts does not specifically regulate noise from wind turbines, but wind energy facilities are subject to Massachusetts Department of Environmental Protection air pollution regulations, which limit sources of noise to 10 decibels over ambient sound levels.

More information: Commercial and industrial operations, including power plants, must meet state noise limits, as measured by decibel-level output. Wind energy facilities are subject to existing noise limits, or new limits are designed specifically for utility-scale wind (i.e. local by-laws). These limits can be based on the ambient decibel level, which is the amount of background noise that the area experiences on a typical day. Noise-producing operations are not allowed to exceed a specific decibel limit, or they must not exceed a specified number of decibels above the normal ambient levels. Massachusetts air pollution regulations (310 CMR 7.10) state that activities and facilities cannot exceed 10 decibels over ambient levels. Some feel this limit is too high, and others suggest that decibel levels alone may not be an appropriate way to measure wind turbine sound. Wind turbine sounds and ambient noise levels both increase as wind speed increases,

so wind turbine noise may be more discernable when wind speeds are low and the difference between wind turbine sounds and ambient levels is greatest (Rogers et al. 2006). Loudness is not necessarily the only nuisance caused by sound. The fluctuating nature of sound produced by wind turbines, even at low decibel levels, may contribute to annoyance for some individuals.

Low frequency sound and infrasound

The issue: Some people have stated that inaudible sound created by wind turbines can cause physiological health impacts.

More information: Sounds at frequencies below 200 Hz are referred to as “low frequency sound”; examples of low frequency sound include industrial sources, like pumps, fans, boilers, or distant traffic. When low frequency sound drops below 20 Hz it is commonly called infrasonic sound, or infrasound. A subset of low frequency sound, infrasound is generally below the threshold of human hearing, but may be audible when produced at more than 70 decibels (Colby et al. 2009). Infrasound also exists naturally in the environment, so it is difficult to attribute different levels of infrasound to specific sources, such as wind turbines. Some people have

stated that they can feel vibrations or pressure, which they attribute to wind turbines, and these tangible impacts have come to be associated with low frequency sound and infrasound by some stakeholders. Whether or not low frequency sound and infrasound, specifically created by wind turbines, negatively impacts nearby residents is currently an issue that requires further study (Acoustic Ecology Institute 2009).

Turbine noise and health

The issue: Some people report that they suffer from health problems, such as sleep disturbance and headaches, which they attribute to sound from wind turbines.

More information: People experience sound differently. Some people live near wind turbines and do not appear to notice them, hearing no sound or are not bothered by the sound they do hear. Other people live just as close, or even further away, and are impacted by sound from the turbines. Some people report that they suffer from symptoms of sleep disruption and/or severe stress, which they attribute to turbine sound (i.e., they believe the sound disrupts their sleep and causes stress, leading to other health impacts). Physical and mental ailments can result from stress and lack of sleep, but there is debate over the extent to which these health problems can be attributed to the sound created by wind turbines. A recent expert-panel review of the peer-reviewed literature found “no evidence that the audible or sub-audible sounds emitted by wind turbines have any direct adverse physiological effects” (Colby et al. 2009). Some published studies have noted a lack of research on the health effects of long-term exposure to low levels of low frequency sound, the impact of wind turbine sound on sleep physiology, the efficacy of currently used setback limits, and epidemiological comparison of health status before and after wind farm development (NCCEH 2010).

Turbine-sound management and mitigation

The issue: There are siting, technological, and operational strategies to manage wind turbine sound.

More information: Most machinery makes noise when it operates. Methods for mitigating this noise have been developed and adopted into regulations and development best practices. However, wind turbines are not the same as factory engines or mobile sources, such as trucks or airplanes. Turbines are designed to operate when the wind blows at sufficient speed, regardless of time of day. Additionally, different turbine models from different manufacturers have different sound signatures. As a first step, sound must be modeled and analyzed to understand the unique sound characteristics of each project, based on a specific turbine model in a specific location.

With proper analysis, pre-construction planning and technological strategies can be used to mitigate turbine sound impacts. In the design and siting stage, employing distance setbacks and careful consideration of turbine locations are an option, although different places have different acoustic characteristics. Once the turbines are operating, technologies can be employed that allow some turbines to operate more quietly, including automatic controls to slow the speed of blade rotation or to prevent rotation speed from increasing excessively, even in very strong winds. Technological sound management options may also be available, such as active noise cancellation, and communities considering wind turbines can work with experts to examine the best available means for managing sound.

Birds, Bats, and Wind Power

The impact of wind power on birds and bats has received much public attention and is the subject of ongoing research. Some impacts have been reported at some land-based wind power facilities in the US. Better understanding of the causes of and contributors to wind-power-related impacts on birds and bats is critical to design effective mitigation strategies. At the same time, it is important to evaluate wind power's wildlife impacts in the context of other threats to avian and wildlife species, including global climate change, which wind power can help mitigate.

Bird and bat impacts

The issue: Land-based wind turbines can kill birds and bats, though fatalities vary widely across species, wind power facilities, and regions of the country.

More information: Land-based wind power can kill birds and bats directly, through collisions with wind turbines, meteorological towers, and transmission lines—and, for bats, through air-pressure-related injuries (barotrauma) from wind turbines. Birds may also experience indirect impacts from wind power, including habitat disruption and abandonment, avoidance of an area, reduced nesting or breeding density, or behavioral changes.

About 75% of bird deaths at US wind power facilities are migratory songbirds that collide with wind turbines. Despite individual bird deaths, several studies have found that wind farms do not have population-level impacts on most bird species (Kuvlesky et al. 2007). While some early wind power projects—most notably the Altamont Pass wind farm in California – have caused significant deaths among raptors and have received much public attention, most US wind farms have relatively low raptor fatality rates (Erickson et al. 2001). Several studies have noted that siting wind turbines away from migratory routes or areas where raptors concentrate may reduce raptor collisions.

Several bat species appear vulnerable to wind turbine collisions, though data on bat fatalities is limited, and the impact of wind power on bats is less well understood than its effects on birds. The majority of bats killed at US wind power facilities belong to three migratory tree-roosting species, and wind-power-related bat deaths appear to peak in late summer and early fall, when many bat species migrate. More research, including site-specific studies, is needed to understand how landscape characteristics or proximity of wind facilities to landscape features influence the rate of bat fatalities and to determine whether wind-turbine fatalities present population-level threats to bats.

Wind-power impacts vs. other causes of mortality

The issue: The percentage of bird deaths caused by wind power is miniscule relative to all man-made causes of avian mortality.

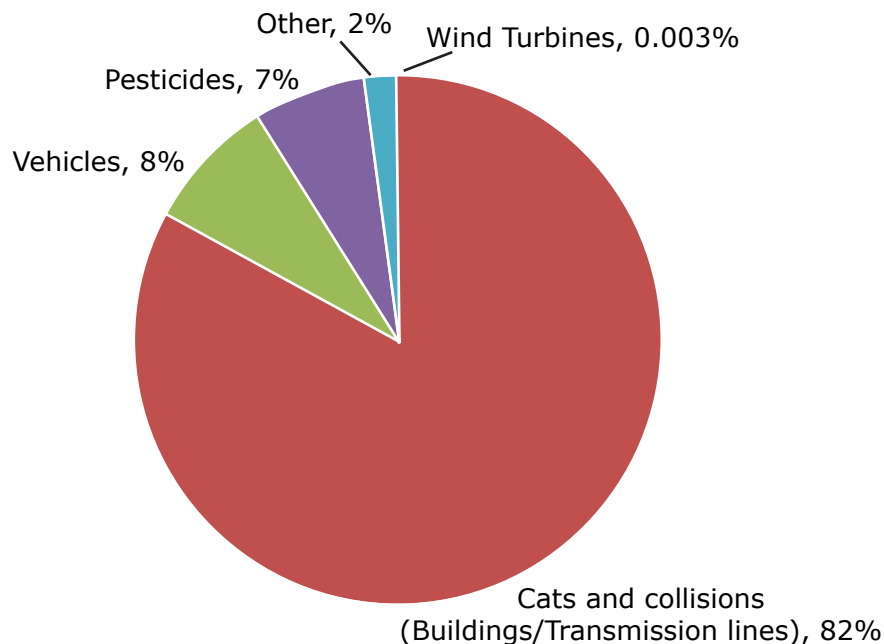
More information: Of the approximately 500 million to 1 billion birds killed annually in the US from all human-influenced causes, an estimated 0.003% are killed by wind turbines, compared to 82% by cats and collisions with buildings and power lines, 8% by vehicles, and 7% by pesticides (Erickson et al. 2005). Put another way, that's less than one wind-power-related bird death for every 10,000 birds killed by other human causes and cats. Looking at the full lifecycle impacts of US

electricity generators and comparing bird deaths per kWh of electricity produced, one study estimated that wind farms were responsible for 7,000 bird deaths in 2006, compared to 327,000 due to nuclear power facilities and 14.5 million due to fossil-fuel-fired power plants (Sovacool 2009).

Recognizing the serious threat of global climate change to birds and wildlife worldwide and the role of wind power to help mitigate climate change, some national and state bird, bat, and wildlife conservation organizations have issued statements of support for responsibly-sited wind power projects that seek to minimize negative impacts on birds and wildlife. The Massachusetts Audubon Society (2003) states, “Mass Audubon

supports the responsible planning, permitting, and production of renewable energy resources including wind energy. We believe that renewable energy resources are essential to the environmental well being of our nation and planet. Such facilities, however, must be conditioned to minimize adverse impacts to living resources.” The American Bird Conservancy (2011) supports mandatory federal wind standards to ensure that wind power is “bird-smart” and “employs careful siting, operation and construction mitigation, bird monitoring, and compensation, to reduce and redress any unavoidable bird mortality and habitat loss.”

Bird Mortality from Human Activity



Source: Erikson et al. 2005

Property Values

Property value can refer to either the market value of property or the assessed value. Market value is essentially the highest price a buyer would pay in an open, competitive market. Market value can be based on both physical characteristics of the property and surrounding area as well as perceptions about the property and surrounding area. The assessed value is generally based on a formula at the state or local level that assesses a certain amount of value per square foot and is used for real-estate tax purposes. Discussion of wind energy and property value may refer to either form of value.

Impacts to the market value of property

The issue: Utility-scale wind turbines can influence factors that are weighed when assigning value to property. Some factors that impact property values are more subjective than others, such as neighborhood character. Other factors are more concrete, such as the existence of nuisance conditions. There is general consensus that property near perceived nuisances is valued less (e.g., property near landfills).

More information: The debate about the impacts of wind energy on market property values tends to be based on the assumption that wind energy will negatively impact the character of an area as well as introduce a nuisance condition. Some studies discuss predicted impacts while others discuss actual impacts; some rely on statistical evidence across broad samples while others refer to specific, one-off examples. Ultimately there appears to be no conclusive evidence of widespread impacts, either positive or negative. The Lawrence Berkeley National Lab (LBNL) conducted one of the more comprehensive statistical studies on property value impacts (LBNL 2009). The authors found no statistically significant evidence of negative impacts on property values. Essentially, based on the review of a relatively large number of examples, there was no consistent evidence of a loss of value. This does not mean that all

properties retained full value; rather, this result allows for the possibility that some small number of properties did experience a loss of value. This is acknowledged by the report authors, who further suggest that additional studies would help promote a better understanding of wind energy impacts to property values, especially with respect to nearby properties.

Impacts to the assessed value of property

The issue: The assessed value of property tends to be based on formulas contained in state or local rules that apply to conditions on the assessed property, such as the size, number, and type of structures. It is less dependent upon nearby activities.

More information: The assessed value of property near turbines does not appear to change due to the proximity of turbines (i.e., structures that are not on the assessed property). However, the assessed value of property may change if turbines are constructed on the property since this would mean physical structures have been added to the property. Reports indicate that assessors did not decrease the assessed value of property near wind turbines in real, post-construction situations (ECONorthwest 2002).

Public Engagement in the Siting Process



Whether you are a community leader, wind developer, or engaged citizen, you have an important role in ensuring wise wind siting decisions.

Turbine at Mark Richey Woodworking, Newburyport, MA. Image credit: Mark Richey Woodworking.

In addition to the issue-specific information above, this guide aims to provide general resources for structuring a broad-based community engagement and review process for siting wind energy. Regardless of the particular questions or concerns that arise in your community, these tools and recommendations will help to ensure that a fair and credible process is used to engage and inform local stakeholders.

A typical wind energy project is subject to many layers of formal governmental approval, from local ordinances to state (and sometimes federal) agency review. Many of these approval processes require public hearings to collect comments from citizens as officials determine a project's compliance with applicable laws.

Since policies around wind energy siting are still evolving in many communities, simply complying with existing laws is no guarantee of project success. Siting regulations are also generally

designed to be responsive to local concerns, so strong opposition may derail a project that looks viable on paper.

Because of the complex nature of energy siting, wind developers and public officials have a responsibility to create opportunities for information sharing, dialogue, and careful decision-making. Communities need reasonable time and space to digest information, discuss a project's implications, and clarify their values and priorities as they relate to the project's costs and benefits, regardless of whether the proposal comes from a private developer or the community itself.

Strong home rule traditions in Massachusetts mean that local support is critical for project success. Community support for wind energy developments arises in part from a sense that residents are heard and their legitimate concerns are adequately addressed, and from benefits being effectively communicated to all stakeholders.

Principles for Wind-related Consensus Building

Although unanimous support for any development project is unlikely, seeking as much consensus as possible in the planning process will reduce conflict and other hurdles in formal permitting processes. Professional outreach support has successfully been used to enhance engagement in many larger scale projects. The recommendations below have been proven to increase agreement among involved parties in wind siting decisions:

1. Initiate stakeholder involvement process as early as possible and set realistic but firm timetables.
2. Include broad representation of legitimate stakeholder groups (including government agencies, and for site-specific projects, local citizen groups).
3. Consider using professional neutrals to facilitate collaborative decision-making.
4. Do not exclude contentious issues; instead, seek ways to address negative aspects of any proposal (including compensation or contingent agreements that specify a remedy in case of an undesirable scenario).
5. Consider incorporating alternative siting processes (such as voluntary public outreach processes, preapproval for specific sites, competitive solicitations from multiple developers).
6. Structure stakeholder involvement processes to supplement but not supplant a formal backstop process, while modifying formal processes to better accommodate consensus-building opportunities.

Source: Raab and Susskind 2009

Common Pitfalls to Successful Wind Siting

The Consensus Building Institute (CBI) and Raab Associates, Ltd. have identified a number of reasons why decisions about wind energy are typically so difficult:

1. Stakeholders: Many current processes do not adequately identify and engage stakeholders and citizens.
2. Interests: Many current processes do not adequately surface or address stakeholders' interests.
3. Perceptions: Different perceptions of aesthetics and noise are difficult to resolve.
4. Facts: Many processes use technical data and analyses that are not credible and salient.
5. Forecasting: Stakeholders argue about different views about the role wind energy will play in the future.
6. Jurisdiction: Differences in goals and policies exist between various levels of government.
7. Duration: Timelines are long and parties, issues, and politics may shift.
8. Transmission links: Integration and interface between wind and the electric system are more complex than with traditional generation.

Source: CBI/Raab Associates. Ltd. 2011

How to Site Wind Successfully AND with Stakeholder Input & Support

A 2010 survey by the American Planning Association asked local officials about the policies, strategies, or actions regarding wind energy implementation that had worked best for their communities when making decisions about projects. The most helpful approaches included:

- Having a good local ordinance that addresses wind energy, whether this meant writing a new set of regulations for wind or updating an existing wind energy ordinance.
- Providing a process that conveys accurate, meaningful information about wind projects.
- Taking field trips to existing wind energy projects.
- Inviting wind energy developers to give presentations.
- Disseminating wind energy fact sheets.
- Demonstrating the financial benefits of wind turbines.
- Keeping the public involved.
- Fostering a cooperative relationship between residents, local government, and wind energy developers.

When a community is involved early on in the planning and permitting process, and when the residents themselves can share in the benefits of the project when built, the odds of siting success are far greater.



Berkshire Wind dedication. Image credit: Massachusetts Municipal Wholesale Electric Company.

Processes that worked

Case Study - Hull, Massachusetts

The town of Hull installed Massachusetts' first modern wind generator, a 660 kW turbine owned and operated by the Hull Municipal Light Plant. The stakeholders who participated in the decision-making process report that the public was involved at every step. The process that Hull used built trust with citizens by being deliberate and consulting with knowledgeable third parties who were familiar with the technology and the issues, but were not in a position to profit from the outcome. Town residents recognized that the energy produced by the turbine would benefit the town directly, by reducing the amount of energy the town needed to purchase from outside sources. The light plant also decided to use part of the "profit" from the wind turbine to cancel the bills to the town for the street lights (UMass-Renewable Energy Research Lab 2003). In May of 2006, a second (1.8 MW) turbine was commissioned, resulting in over 10% of the town's entire consumption of electric energy being supplied by these two turbines.

"People often ask us why we did not encounter more local resistance. I'd like to think that the answer is in part because we sought the input of local community leaders and residents before the project research and planning ever made it to the press...I've lived in this community for 30 years, and I live within one mile of the turbine. All of the community's questions were my questions, and so this part of the process was very important."

-Brian Fairbank, President/CEO, Jiminy Peak Mountain Resort (Wind Powering America 2008)

What made Hull such a success?

- Municipal electric utility that was an active participant in the process
- Local champions
- Good wind resource
- Public involvement
- Past experience with wind energy
- Town realized public benefit
- Available site
- Technical support

Source: UMass - RERL 2003

Case Study - Jiminy Peak Resort

In 2007, the Berkshires' Jiminy Peak Mountain Resort installed a 1.5 MW GE wind turbine that is now generating a full third of the ski resort's power. The resort's management began public engagement by hosting a coffee hour to discuss management's plans and objectives and ask for the community's feedback. As a result of this initial meeting, the conversation about the project was framed as a local business proposing a project to protect local jobs, be an environmental leader, and send a positive message to the region.

The turbine generates 4.6 million kilowatt hours (kWh) of energy annually. Most of the power is generated in winter, when mountain winds peak and demand at the resort is at its highest, due to the demands of snowmaking equipment.

A renewable energy grant from the Massachusetts Technology Collaborative for \$582,000 helped offset the \$3.9 million installed cost of the turbine. During periods when the mountain doesn't need the electricity, power is sold back to the power company. Jiminy estimates it will earn an additional \$161,000 annually from selling power in the spot market through National Grid and \$46,000 in production tax credits (Wind Powering America 2008).

Tools for Sharing Information and Seeking Common Ground

A variety of tools and techniques have been successfully utilized to improve stakeholder and citizen understanding of potential wind energy development and to seek meaningful feedback. These tools are summarized briefly below, and more information about these tools and techniques is available at *The Consensus Building Handbook: A Comprehensive Guide to Reaching Agreement* edited by Susskind, McKeatnan and Larmer (1999).

Conflict/situation assessments

A neutral, third-party first identifies and then interviews key stakeholders (including representatives of citizens groups) to identify both their interests and concerns regarding the development of wind in their community generally and potentially at specific sites. The interests and concerns are summarized in a document that is then presented and made available to the community and the potential developers.

Joint fact finding

This process involves engaging stakeholders in defining what information they need to evaluate the benefits and costs of wind development in their communities, and then keeping the community engaged as the information is gathered and analyzed. It could include stakeholders' input in aspects such as consultant selection and model identification or specification.

Using visual simulation tools, overlay techniques, and other tools

Visual simulation tools help communities visualize what wind developments would actually look like at specific sites (from different angles, under different lighting conditions, etc.). Overlay techniques are used to help identify the most and least suitable wind sites by mapping items of interest on top of each other, such as wind speeds by location, sensitive and protected habitat, and accessibility to transmission lines and roads. These tools can be used to assist in the joint fact-finding process.

Interactive engagement techniques and tools (e.g., keypad polling, charrettes)

Planning charrettes and visioning exercises can be used to help citizens clarify their aspirations for a project's outcomes. Polling can help collect information about community preferences. However, polling is more meaningful when it is preceded by educational material and a forum where participants get a chance to learn more about the issues or proposals first, then have an opportunity to ask questions themselves and engage in discussion with their peers and experts.

Negotiated rulemaking

Negotiated rulemaking is a process to develop new policies and rules for a local, state, or federal agency. Stakeholders are invited by the agency to negotiate the details of a new rule or policy. By including the full spectrum of stakeholder representatives, negotiated rulemaking can improve the practicality and legitimacy of new rules and policies.

Facilitation/mediation

It is often useful to bring in a professional facilitator or mediator to help government agencies, developers, stakeholder groups, and citizens design and run public engagement processes. Facilitators and mediators are non-partisan—working on behalf of all those involved—to ensure a fair and effective process.

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