A Brief Review of Wind Power in Denmark, Germany, Sweden, Vermont, and Maine: Possible Lessons for Massachusetts

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INTRODUCTION AND BRIEF SUMMARY

The purpose of this supplementary report is to provide a brief overview of wind power in three countries (Denmark, Germany, and Sweden) and two states (Vermont and Maine), with a focus on determining if there are any possible best practices and/or lessons for Massachusetts to consider. These three countries were chosen because they have made a strong commitment to renewable energy and have at least several years' of experience with wind power. The two states were chosen for their experiences with wind power and their proximity and similarities to Massachusetts.

A brief profile of each country or state reviews the current status of wind power and provides such information as: how many wind turbines exist and how much electricity is produced by them; any stated goals for expansions of wind power; current health-related regulations related to wind turbines; if there is any government or other official record of health complaints related to wind turbines, and if so, how these complaints have been handled.

The conclusion provides some thoughts about aspects of these five profiles that could be considered a best practice for Massachusetts to consider, and any lessons learned from these profiles.

To briefly summarize, this review revealed some processes used by these other jurisdictions that appear to result in greater success in expanding wind power as a renewable energy source in the range of Massachusetts' goals. The processes identified in Denmark, Germany Sweden, and Vinalhaven Island in Maine are especially noteworthy, and more details are included in the conclusion and profile sections of this report. In brief, they include:

- **Local planning efforts aimed at achieving national renewable energy goals** drive the decision-making process in especially two of the countries. As a result, wind power is seen alongside alternatives to achieve those goals. Such local planning efforts are either required or strongly incentivized. Tools and policies provided by national or regional government entities, such as community mapping tools to determine appropriate wind turbine sites and market-driven certificate systems, assist local planning efforts.

- **Community engagement** includes a variety of possible community benefits, such as: receiving electricity directly from the wind project; having opportunities to purchase shares of nearby wind projects; being compensated for loss of property value; seeing local jobs created by wind power; and receiving resources to support community-owned wind power associations.

- **Multi-pronged setback regulations** include: a measured setback based on safety factors such as ice throw; and a setback based on noise levels, calculated on two different wind speeds to take into account higher turbine noise levels at low-moderate wind speeds; and setbacks based on shadow flicker. A new Danish regulation related to low frequency noise is an emerging issue.

CONCLUSIONS FROM THE PROFILES

Each of these three countries and two states present some possible best practices for Massachusetts to consider, given the state's renewable energy goals, and specifically wind energy goals.

1. Denmark: An Overall Best Practice

Denmark has several decades of experience with wind power since the 1970s, and over a geographical area of buildable land that is not much bigger than Massachusetts, has over

5,200 wind turbines generating about 20% of their electricity. The setback regulations due to noise and national goals for renewable energy are similar to those found in some other states and countries. However, the major differences between Denmark and many of these other locations is in their decision-making process, level of community engagement and benefits, and their multi-pronged setback regulations.

Denmark views wind power in the context of a major transformation, a metamorphosis of the entire society, from fossil fuels to renewable energy sources that in some ways has the flavor of a national campaign with strong grassroots. This transformation's appeal resonates with national pride, as Denmark views the goal of energy independence as an achievable victory over fossil fuels, that are characterized as being high-priced, economy-draining, climate-changing, and with an overall unstable and diminishing global supply.

Of the five entities profiled, Denmark has pursued wind energy most aggressively. In only about 20 years' time, wind power has grown from producing 2% to 20% of the country's electricity. With a large majority of its 5,200 wind turbines built on land and more being built every day, it is noteworthy that opposition to them does not appear to be strong, or at least strong enough to slow down the country's large investments in this technology.

Danish success with wind power seems to be due in part to an aligned consensus by community members, municipal and national governments, and others that wind power is a major strategy in the transformation of the society to renewable energy sources. There is also a strong link made between energy, the environment, and the economy. As one Dane said, "Whenever we pay for a car's gas tank to be filled, we are paying for jobs elsewhere in the world and contributing to climate change. Wind power generates Danish jobs and helps bring the world's temperature down to normal."[i]

While the country has made large investments to support wind power, communities are very engaged. Renewable energy, highlighted by wind power, has become an economic engine, employing a number of Danes in the building and even exporting of this technology. Municipalities are responsible for developing energy plans that meet renewable energy targets. Community mapping that indicates suitable areas for wind turbine placement provides an up front process between regulators and residents, before developers are involved. Community members receive a number of direct benefits from the wind turbines, including: receiving electricity directly from them; having opportunities to purchase shares of nearby wind projects; being compensated for loss of property value if their homes are close by; and resources to support community-owned wind power associations. They also recognize that with wind power continuing to expand in Denmark (with expansions increasingly taking place off shore), there are other possibilities within reach, such as fueling the country's transportation infrastructure with wind power. For instance, investments in electric car infrastructure are already taking place.

Danish setback regulations have several factors worth considering: a measured setback (4 times the height of the turbine); a setback based on calculated noise levels, and with

two different wind speeds to take into account higher turbine noise levels at lower wind speeds; and emerging rules that account for the annoyance caused by low frequency noise.

This multi-pronged approach for calculating setbacks along with strong community engagement marked by shared investment and direct benefits, seem to set Denmark apart from many other areas.[ii]

2. Germany: Some Best Practices to Consider

Over the last 20 years, Germany has enacted a number of coordinated policies that have served to greatly accelate the use of renewable energy sources, such as from wind. These policies include those regulations of utilities, incentives such as tariff structures for renewable energy, community mapping designating areas for wind turbines up front, and comprehensive noise and siting regulations.

Additionally, public engagement in Germany has been prominent, including widespread education about renewable energy, research involving the country's educational and other institutions, and incentives for community and other ownership (such as by farmers) of wind turbines.

3. Sweden: Some Best Practices to Consider

Although Sweden's experience with wind power is more recent, like Denmark and Germany, they are aggressively pursuing wind as a main source of renewable power. Also, like Denmark, there is a strong partnership between national and municipal governments, with communities engaged in determining how they are to meet renewable energy goals.

Swedish researchers such as Eja Pedersen have had an influence on how wind turbines are sited and planned for in Sweden as well as other countries.

The multi-pronged policy approach in Sweden can also be considered a best practice. Such policies include those at the national level that result in a renewable energy plan with goals, a system of regional coordinators, and a market-based certificate system. The market-based certificate system has been cited as a very successful approach to driving the market toward renewable efficient energy sources. At the local level, policies result in communities planning and meeting renewable energy goals.

4. Vinalhaven, Maine: Some Best Practices to Consider

In both Maine and Vermont, there are requirements on wind power developors to provide community benefits. However, there is not the degree of community engagement as required in Denmark (which requires municipalities to review their energy profile and meet renewable energy goals, offers opportunities for nearby residents to purchase shares

of the wind power project, supports community-owned wind power associations, compensates nearby property owners for a loss of property value and has assurances that electricity produced by wind turbines provide power to the community).

One project in Maine may come close to the Danish model, and that is Vinalhaven. Despite some noise complaints and voiced health concerns from some nearby residents, the Vinalhaven Island's Fox Islands Wind Project enjoys strong support by both islands it serves, from both anectdotal and previously-mentioned survey information.

Unlike other wind projects in Maine and Vermont, this project emanated from the islanders themselves. A community collaborative oversees the project, and the islands' residents obtain their electricity from the wind turbines. It seems these similarities to the Danish successes with wind power may be noteworthy.

5. The Importance of Context

Over the last 10 years, Maine has made a strong commitment to pursuing renewable energy sources, with a focus on wind power. State statute and policies have codified this commitment. Vermont, like Massachusetts, is early in its pursuit of wind power and has made a strong commitment. However, all three states share a growing resistance to wind power, with much of it focused on health concerns related to noise from the turbines.

Both Maine and Vermont have processes for the public to provide input to specific wind power projects. However, this input is focused on whether a wind project is acceptable to local residents, with a resulting focus on any potential risks from wind power without a counterbalance focus on the risks of the alternatives. In Maine and Vermont, as in Massachusetts, statute makes policy assertions about the benefits of renewable energy, and in some ways frontloads the discussion.

By contrast, Denmark and Sweden's local input is focused on comprehensive energy planning, including meeting nationwide renewable energy goals, and how a community will achieve such goals. Wind power, with both its benefits and challenges, is positioned with alternatives, such as oil, coal, nuclear, and hydro power as well as energy conservation.

When these alternatives are seen together, it is clear there are no no-risk options. Reliance on fossil fuels results in more asthma, worsening heart disease, and further global climate change. Nuclear power results in challenges related to safe locations of power plants and long term storage of nuclear waste. Hydro power poses challenges with environmental disruptions. Decisions at the local levels in Denmark and Sweden are made by considering the pros and cons of each, in the context of a planning process to achieve renewable energy goals.

Wind power initiatives in there profiled areas are also deeply rooted in national or state plans that position wind power in the context of high-priced fossil fuels (with global

supplies only diminishing and prices increasing further) and global climate change. Denmark and Sweden's policies and processes result in this context being brought to wind power discussions at all levels, including the local community level.

Indeed, it seems like an important lesson from these three countries is that in order to achieve stated goals, wind power discussions need to be conducted in the context of a link to fossil fuel prices and global climate change; and decisions about wind power need to also be positioned alongside alternatives.

PROFILES

DENMARK

Denmark has a population of about 5.5 million and a land size of 16,600 square miles. The population is a bit less than Massachusetts' 6.6 million, and although the size appears to be about twice as big (Massachusetts has 7,800 square miles), because of the large number of islands with extensive shoreline in Denmark, the buildable square mileage is much less than the total land size.

The hallmark of Denmark's energy policy is independence from fossil fuels. In fact, the Danish Government's February 2011 Energy Plan, called "Energy Strategy 2050: From Coal, Oil, and Gas to Green Energy", states this overall goal in its title. The first sentence in the plan states, "The 20th Century was largely driven by access to cheap and plentiful coal, oil, and gas. However, in the 21st Century we will have to find other means of satisfying our energy needs." The plan goes on to state its main goal is independence from coal, oil, and gas by 2050, which in turn will result in Denmark maintaining a secure stable supply of affordable energy and helping to limit global climate change. In addition, achieving this goal will provide economic opportunities for Danish green energy technologies within its own borders as well as in the global market, and will minimize Denmark competing for a shrinking supply of fossil fuel supplies, many of which are in unstable countries.[iii]

Denmark is one of the most aggressive countries in the world for wind power and has a relatively long history using it. Since 1988 Denmark has built nearly 3,400 MW of wind capacity. Currently, wind power provides about 20% of Denmark's electricity through more than 5,200 wind turbines, and this is an increase from 2% in 1990. The vast majority of this wind turbine-generated electricity is onshore, but as available land is becoming scarce, an increasing number of wind turbines are found in offshore wind farms.

According to the Danish Energy Agency, this aggressive approach to wind power has reduced the country's dependence on fossil fuels and has made Denmark one of the largest European energy technology exporters. Their data show that since 1980 Danish GDP (Gross Domestic Product) has increased by 78%, their energy consumption has

remained flat, and their CO2 emissions have decreased by more than most any other European country.[iv]

Denmark's goal is to meet 50% of its electricity needs with wind energy by 2025, including a near doubling of their wind power capacity to 6,000 MW. They are also investing in the infrastructure to support electric cars, so that wind power will be powering some of their transportation needs.

A search of the Danish governmental websites for environment and health do not indicate there have been significant health issues that have risen to their attention and placed on an official record. These agencies acknowledge that wind turbine noise can be annoying or troubling, especially at lower wind speeds, which is why they require calculating noise levels at both low and higher wind speeds.[v],[vi]

The newer wind turbines in Denmark have an electrical output of 3.6 MW, have a hub height of 295 feet (90 meters) and a total height of 471 feet (143.5 meters). Municipalities in Denmark are the planning authority for onshore wind turbine developments and also oversee enforcement of applicable laws. They are responsible for meeting nationwide goals for renewable energy. National regulations overseeing the municipal process ensure that residents and stakeholders are engaged in the planning process. The Danish Ministry of the Environment has a Wind Turbine Secretariat to assist municipalities with this process. Municipalities are charged with designating areas suitable for large wind turbines. The project approval process usually takes about one year.

According to the Danish Environmental Protection Agency website, mapping has been a very helpful tool. Areas of Denmark are mapped and color-coated to indicate which areas are not suitable for wind projects, and which are. This has resulted in an up front process for determining sites with regulators and residents, before developers are even involved.[vii]

Wind power in Denmark since the 1970s has received supplemental funds paid by the ratepayers due to wind's inability to compete financially with coal, natural gas, or oil. However, the Danish agencies mention counterbalancing issues, such as: the true cost of fossil fuel dependency, including detrimental environmental and health ramifications; the gradual lowering cost of wind power due to technological advances; and the economic benefits of Denmark's ability to export produced energy as well as turbine-related technologies and products.[viii]

In terms of health-related regulations, such as setbacks, Danish regulations require a minimum distance from nearby residences to a wind turbine of 4 times the total height, with no ability to waive this limit.[ix] Regulations also require a noise survey to be carried out and the sound pressure levels calculated at neighbors' properties.

For sparsely populated areas (countryside), 44 dBA is the noise limit for wind turbines, calculated for the area outside a neighbor's house at an outside wind speed of ~18 mph (8

meters/second), as well as at 42 dBA at ~13 mph (6 meters/second). Outside wind speeds are calculated for 10 meters above the ground.

For residential areas, the limit is 39 dBA at wind speeds of ~18 mph (8 meters/second) and 37 dBA at ~13 mph (6 meters/second).

The Danish noise limits refer to an averaging time between 1 – 10 minutes. The sound emission from wind turbines is measured in a series of 1-minute periods, and according to Danish regulation, at least five periods in each of the wind speed intervals 5,5 - 6,5 m/s and 7,5 - 8,5 m/s are to be measured and averaged.

Up until now, Danish regulations have not addressed low frequency noise (10 – 160 Hz), since their Environmental Protection Agency has not felt this constituted a problem when Danish regulations are abided. However, in response to requests by stakeholders, new rules related to low frequency noise were promulgated in 2011 and went into effect January 2012. These rules provide a 20 dB indoor nighttime limit for low frequency noise during wind speeds of 6 and 8 meters/second, which equals ~20 and 26 feet/second applied to newly proposed wind turbines. Note that other Danish noise limits are calculated or measured outdoors.[x] The agency website states: "no evidence suggests that low frequency noise is more dangerous than other forms of noise." The agency also states that: "When infrasound (they define as 'very low frequency') is audible, it becomes annoying. Where infrasound is inaudible, it does not affect health."[xi]

In terms of the process for approval and siting of wind power facilities in Denmark, their Environmental Protection Agency describes the process: "the development of wind power in Denmark has been characterized by strong public involvement."[xii] Danish law contains several relevant strategies:

- Nearby property owners are compensated for any loss of property value due to the wind turbines;
- Local citizens' (living within 2.8 miles = 4.5 km) have an option to purchase wind turbine shares;
- Subsidies are given to communities with wind turbines;
- Up front mapping that indicates suitable areas for wind turbine development means decisions are made with regulators and residents, before developers are involved.
- Funds support financing of the analysis and planning for wind turbines by local wind turbine owners' associations (in which a majority of members are residents of the municipality where the association's wind turbines are planned or located);
- Investments are being made in electric car infrastructure.

In terms of health effects from turbines in Denmark, several citizens and officials note that complaints of annoyances coming from nearby residents have occasionally been seen, but they have not been viewed as very common or severe. One official notes, "As to health effects of noise, the Danish EPA follows the topic, and to our knowledge this type of noise has no different health effects from other types of noise. Since the Danish noise limits are low in comparison to noise limits for traffic noise, we expect that wind

turbine noise has no serious health effects. Recent literature reviews by the Danish company DELTA in 2011 (in request by the Danish Board of Health), by the Dutch institute RIVM in 2009, and by the Swedish Institute of Environmental Medicine at Karolinska in 2011, (in request by the Swedish Environmental Protection Agency) supports this view."[xiii]

GERMANY

Overview

With a land area of 357,114 km^2 and a population of 87,702,000, Germany is one of the largest countries in Europe. Germany has the highest GDP in Europe ($3,315 billion in 2010) and the 4th highest GDP in the world. It also ranks third in the world in total installed wind power (27,215 MW in 2010). In terms of other metrics of installed wind energy capacity Germany also ranks very high. For example, the installed capacity per unit of land area is 76.2 MW/m^2. This is nearly as high as Denmark (the highest), which has 86.6 MW/m^2 and is far higher than the US as a whole (4.2 MW/m^2) or Massachusetts in particular (2.3 MW/m^2). On a per capita basis, Germany ranks fourth in the world with 333 MW per million people. This compares with Denmark (again the highest), which has 695 MW per million people. In comparison the United States has 131 MW per million people and Massachusetts has only 6.9 MW per million people. Germany presently derives 6.2% of its electricity from wind turbines.

History

Germany had a long history of using wind energy, originally traditional windmills but then for electricity in the mid 20th century. In more recent times, however, Germany turned away from wind energy. The meltdown of the nuclear power plant at Chernobyl changed all that. This disaster had a major psychological impact on the Germany, and the country has been moving away from nuclear power ever since. Germany is also taking climate change very seriously, and therefore, has been seeking alternatives to fossil fuels as well. A national goal is now to supply 100% of Germany's electricity from renewable energy sources by 2050.

Policies

As a result of the recent historical events Germany noted above, since approximately 1990, Germany has developed a number of coordinated policies that have served to greatly accelerate the rate of deployment of renewable energy generators, including wind turbines. One member of the German Parliament, the late Hermann Scheer, was particularly instrumental in this process. The most important of these policies include the following

1. The *Stromeinspeisungsgesetz* or "feed-in law" of 1990.
2. The Erneuerbare-Energien-Gesetz (EEG) of 2000 (revised a number of times)
3. Revisions to the German building code
4. Implementation of environmental protection regulations

Below is a summary of these policies.

Erneuerbare-Energien-Gesetz (EEG, or Renewable Energy Law)
The key features of the EEG (which also embodies the most important features of the feed-in law) are the following:

1. The utilities are mandated to connect renewable generators to the grid.
2. The utility must upgrade the lines if necessary for the interconnection.
3. The local utility must purchase the electricity according to a set "feed-in" tariff.
    a. Different types of generators (wind turbines, photovoltaics, biomass, etc.) have different tariffs
    b. The rates for the tariffs are set so that they provide a sufficient incentive to make it worthwhile to install renewable energy generators
    c. For wind turbines, the rates are stepped (higher initially, lower later), so as to make wind turbines economically viable in most of the country, but to prevent excessive profits in unusually windy areas. This approach obviates the need to do extensive and expensive site wind resource monitoring before a project is begun.[xiv]

German Building Code

There were two significant changes made to the German Building Code:

1. In general, only certain kinds of structures can be built in the German countryside. In 1996 Paragraph 35 of the building code was revised so that wind turbines are permitted by right in much of the countryside. The result is that the presumption is that turbines are allowed to be installed, unless a reason is presented why that should not be the case. This change obviously makes the permitting process relatively simple and quick.
2. As part of the change, German cities and communities were required to identify wind resource areas within their borders. Such identification also helped to expedite the placement of wind turbines.

Environmental Protection
In parallel with the incentives for installing wind turbines, Germany has also implemented relatively strict regulations regarding environmental impact. Of particular significance are regulations for shadow flicker and for noise. The shadow flicker regulation is the one that the Massachusetts Wind Turbine Health Effect Science Panel has also recommended (maximum 30 minute per day, hours per year). The noise regulation is one of the most stringent anywhere: it limits nighttime sound level to 35 dB(A) in purely residential areas.

Public Participation and Public Acceptance
There are a variety of measures in place that have served to both increase public participation and public acceptance of wind turbines. These include:

1. Wide spread public education
2. Renewable energy education at all academic levels, including high schools, colleges and universities.
3. Research and development activities, involving universities, institutes and industry

4. Incentives for permitting and access to financing, including for cooperative ownership of wind turbines.

One significant feature of this process, which must be considered both a cause and an effect of the general level of public acceptance, is that the majority of wind turbines in Germany are owned by either individuals (including as part of a cooperative) or farmers. The minority of turbines are owned by developers, utilities, investment funds or industry.[xv]

SWEDEN

Although Sweden has a geographical size of 174,000 square miles (compared with 7,800 square miles in Massachusetts), a large proportion of its 9.3 million population live in the southern portion of the country.

In 2009, the Swedish Parliament passed a comprehensive energy and climate change policy and plan. Their stated goal is to be free of fossil fuels by mid-century. Their stated reasons for pursuing this goal include: to contribute to slowing down climate change; to provide sustainable, stable, and affordable energy sources for Sweden; and to improve the long-term economic outlook for Sweden.

Sweden's plan recognizes that renewable energy and economic development are intertwined: "the world faces several interdependent challenges. The climate crisis has coincided with an economic downturn, and the way out of both these crises is an economy which accommodates the environment – an eco-efficient economy." Like Denmark, there is a strong emphasis on energy independence (with renewable energy) not only being healthier but also creating energy jobs within their boundaries.[xvi]

Sweden started discussing and building wind power after the oil crisis of the 1970s and a national debate and referendum on nuclear power in the 1980s. Wind power has increased dramatically since then, from just 1 turbine in 1982 to 1,655 turbines generating 3.5 TWh in 2011.

Although nuclear and hydropower supply most of the electricity in Sweden, over the past several years, these other two sources are on the decline or remain flat, while wind power is increasing at a very high rate. For instance, the vast majority of wind turbines in Sweden have been built in the last 10 years, with wind power generation increasing by 78% from just 2008 to 2010. 208 new wind power turbines were installed with a total capacity of 574 MW in 2010 alone. The average capacity of wind turbines in Sweden is 1.9 MW.[xvii] Wind power currently accounts for about 2.4% of electricity use in Sweden.[xviii] Although most of Sweden's wind turbines are located in the southern portion of the country, which is the most densely populated, most municipalities now have wind turbines.[xix] [xx]

Swedish government support for wind power includes funding regional coordinators who work with municipalities and other stakeholders to provide information and to facilitate the licensing process. Sweden has a comprehensive energy planning process with national targets for renewable energy and a green certificate system, both of which wind power is a part of. Each municipality is also required to create its own energy plan, which includes strategies for meeting the national targets for renewable energy. Most of the land wind power sites are determined by municipalities, and are part of their own energy plans to meet their renewable energy goals.

Sweden's Energy Agency has also produced a map of the country with areas designated suitable for wind power, based on air, soil, water, and other testing as well as on factors such as natural habitat issues. This map is a tool created for municipalities, though wind turbines can also be built elsewhere.[xxi]

Sweden's national energy plan sets the following goals:

The proportion of energy supplied by renewable sources is to be at least 50% of the country's energy use by 2020;

Vehicles in Sweden are to be independent of fossil fuels by 2030 (which includes being fueled by wind power); and

There will be no net emissions of greenhouse gases to the atmosphere by 2050.

In 2009, Sweden approved a plan for wind power of 30 TWh by 2020, of which 20 TWh is to be produced onshore and 10 TWh offshore. Currently, 71 out of 1,655 wind turbines are offshore, and this represents 163 MW.

Sweden has a market-based green certificate system that supports producers of renewable electricity, including wind power. Utilities must purchase these certificates in order to meet their required percentage of renewable energy. Market prices are then set by the supply and demand for these certificates.

In terms of the process for licensing, onshore wind farms are authorized by county or municipal environmental boards.[xxii] [xxiii]

Noise Regulations in Sweden, as of 2011:
Noise recommendations for county and municipal boards for nearby residential and educational facilities are 40 dBA day and night, related to a wind speed of 8 m/s at 10 m height [xxiv] [xxv] It is unclear over what time period (hour, several hours, etc) these measurements are averaged.

Although there is little evidence from the official Swedish websites of overall health effects due to wind turbines, one of the most peer-reviewed published researchers in this field is Swedish. Eja Pedersen, from Halmstad University in Sweden, has published numerous articles emanating from surveys of residents and noise levels in Northern

European communities with wind turbines, many of them in Sweden. Her research has found, for instance, that wind turbine noise is more annoying at the same sound pressures than other transportation noises, and this could possibly be due to its swishing quality or lack of nighttime abatement. She has found a dose response with air pressures, ie the higher the measured air pressures emanating from the turbines, the higher the reported annoyances. Her research has also noted other factors associated with high annoyance levels such as: hilly and rocky terrain; rural location; high visibility from residents' homes; and negative attitude toward wind power.[xxvi]

VERMONT

With about 625,000 people spread out over 9,250 square miles of land, Vermont is much more sparsely populated than Massachusetts.

Vermont has been engaged in a collaborative stakeholder process to develop a new comprehensive energy plan that was released in December of 2011.[xxvii] The plan has three main purposes: to inform the public about challenges Vermont faces to maintain a safe, reliable, affordable, and sustainable energy supply; to examine the current efforts to address these challenges; and to make recommendations. [xxviii]

Although the first megawatt-size (1.25 MW) turbine in the world was installed in Vermont in 1941, Vermont has relatively few wind turbine developments compared with a number of other states.[xxix] However, like Maine and Massachusetts, Vermont is struggling to determine criteria for siting and has seen officially-recorded pushback from nearby residences who have expressed concerns about health-related noise issues.

Vermont Public Service Board is a three member quasi-judicial board that supervises the public utilities in Vermont, including the permitting process for wind power. They also determine the noise levels for each project.[xxx], [xxxi]

The Board oversaw the first commercial wind power facility installed in Vermont, which was also the first one in New England. The facility was completed in 1997 in Searsburg, and consisted of eleven 550 kW turbines with installed capacity of 6.05 MW. A 10-year study of this turbine facility by the U.S. Department of Energy and the Electric Power Research Institute verified the performance of this project, and found that with the average wind speeds of 15 – 17 mph seen on the facility's ridge site, the turbines produce about 12,000 MWh annually, enough to power about 1,700 homes. One of the turbines was recently struck by lightening and is out of service, perhaps permanently.[xxxii]

In August of 2007, the Vermont Public Service Board issued a certificate for UPC Vermont Wind (First Wind, Sheffield) to construct a 26-turbine 40 megawatt wind farm in Sheffield, Vermont. The Board placed restrictions on the noise, limiting it to indoor levels of 30 dBA within any surrounding residences and a nearby school structure.[xxxiii] This project is scheduled to be operational in November, 2011 an is supposed to provide tax revenues of about $500,000 annually to local communities as well as electricity in

Vermont. However, some advocates have requested the Board to reconsider the strategies for measuring sound pressures, saying they are faulty. These requests have been denied.[xxxiv]

Another application for a 4-turbine wind project has been completely denied by the Board. Three other projects are now proposed and before the Board (a 5 turbine project in Manchester, an additional 30-45 turbines in Searsburg, and a 3 turbine project in Milton)[xxxv] (The 1941 wind turbine operated successfully for 1,100 hours, but then failed when a blade broke at a known weak point, which had not been built properly due to war-time shortaages of building materials.)[xxxvi]

Because much of the land that is desirable for wind turbine development is owned by the state or federal government, in 2004, a working group was convened by the state to create a policy on the use of such lands for wind turbine development. They found that because of deed restrictions and the mission of the state steward, the Agency of Natural Resources, it would be inappropriate to develop large-scale wind farms on these lands. This has limited wind power's expansions in Vermont.[xxxvii]

Because of ongoing concerns about noise and related health issues due to wind turbines, the Vermont Department of Health in 2010 conducted a literature review on the topic. In October, 2010 their report concluded, "there is no direct health effect from sound associated with wind turbine facilities." The Department of Health made recommendations: "To protect public health, the Vermont Department of Health recommends that nighttime sound levels from wind turbines be limited to 40 decibels or less, as measured at the exterior façade of the dwelling and averaged over 12 months of exposure. This is consistent with the most recent recommendations of the World Health Organization (WHO 2009).[xxxviii]

Vermont's 2009 Comprehensive Energy Plan acknowledges the difficulties the state and communities have been faced with by people expressing concerns about noise generated from wind turbines and the overall visual impact on the environment. As a result, the most recent plan recommends that the Vermont Public Service Department (the agency home for the Vermont Public Service Board) should:

- identify areas in Vermont that are likely to meet statutory and permitting requirements;
- develop guidelines for towns and individuals that are interested in developing community wind projects; and
- encourage Vermont utilities to participate in regional and international wind projects.[xxxix]

Vermont also has a federally-funded state-sponsored loan program to support small-scale wind projects. About 20 such wind turbines exist with about another dozen planned. Most are associated with schools and farms. These seem to be more widely accepted.[xl]

Vermont's new Comprehensive Energy Plan, unveiled in December, 2011 sets a goal of obtaining 90% of the state's total energy from renewable sources by 2050, an increase from 23% in 2011. This plan's section on wind power concludes: "wind power should continue to be an important renewable resource for Vermont's diverse electricity portfolio going forward." However, there is a focus on community and small-scale projects, and on large-scale wind projects that meet a number of environmental criteria as well as economic and community benefits (no mention of negative health issues related to wind power is found in the report). The plan also mentions supporting more community involvement with energy planning.[xli]

In summary, like Massachusetts, Vermont is early in its pursuit of wind power and has run into local resistance due to health and other concerns. Vermont agencies are also working in partnership with municipalities trying to address these challenges. Ongoing discussions with colleagues in Vermont may lead to shared lessons and solutions, although state agencies there are the lead decision-makers in wind power projects, not municipalities.

MAINE

With 1.3 million people over 33,000 square miles of land, Maine is a large and mostly rural state.

In 2009 Maine released a comprehensive energy plan with the vision of: "To provide leadership in the development of public and private partnerships that aspire to achieve the State of Maine's goals of energy independence and security with clean, reliable, affordable, sustainable, indigenous and renewable resources." The mission includes the "achievement of energy independence, while optimizing Maine's energy security, economic vitality and environmental integrity."[xlii]

Maine's specific wind power goals emanate from the Maine Wind Energy Act, which went into effect in 2004. Major revisions were made in 2009 as a result of the recommendations of a 2007 – 2008 Governor's Task Force on Wind Power Development in Maine.[xliii] The Act sets goals of developing:

- 2,000 MW of wind generating capacity by 2015;
- 3,000 MW by 2020 (including 300 MW from coastal waters); and
- 8,000 MW by 2030 (including 5,000 MW from coastal waters).

The Act also states, "it is in the public interest to reduce the potential for controversy regarding siting of grid-scale wind energy development by expediting development in places where it is most compatible with existing patterns of development and resource values when considered broadly at the landscape level." The Act also added statutory approval criteria to regulate shadow flicker from turbine blades as well as a safety setback based on their review of potential health and safety impacts from these types of facilities.

The Act also includes a state expedited permitting process overseen by the Maine Land Use Regulation Commission (who oversees land use in unorganized areas), the Board of Environmental Protection, and the Maine Department of Environmental Protection (Maine DEP). Maine DEP must issue a decision on most major wind projects (which are generally those with three or more turbines) within 185 days.

In addition to State approval, Maine's almost 500 municipalities, because of Home Rule, may pass ordinances that are stricter than state statute, and may even place a moratorium on wind power development. Private for profit wind developers of projects with 20 MW or more of projected capacity must develop an agreement with the host community (municipality or county) for at least $4,000 per turbine per year (averaged over 20 years) of benefits, which are listed as including property tax payments, reduced electrical rates, land conservation, etc.

Projects subject to municipal permits with more than 100 kilowatts of wind generating capacity must comply with Maine DEP noise standards and avoid shadow flicker effects. Municipalities not wishing to have their own ordinances may elect to have the Maine DEP certify a project with less than three turbines (that would not otherwise be subject to the state standards for wind projects) as being in compliance with state standards, where municipalities must then enforce those noise and flicker regulations.[xliv] [xlv] [xlvi]

The text of Maine DEP's noise rules, which govern wind projects with more then three turbines, promulgated in 1989, recognize that excessive noise can degrade health and welfare of nearby neighbors. Routine operations of a proposed development are limited to 75 dBA at any time; to 60 dBA during the daytime; and to 50 dBA during the nighttime for non-commercial and non-industrial areas; and to 55 dBA daytime and 45 dBA nighttime for areas in which ambient sounds are 45 dBA or less daytime and 35 dBA or less nighttime. Therefore, most wind projects are subject to a 45 dBA nighttime noise limit. These measurements represent an hourly average.

Maine also requires a safety setback of 1.5 times the height of the wind turbine.

Currently, there are seven wind turbine farms operating a total of 173 wind turbines with a total size of 325.5 MW. 43 additional turbines across 3 approved wind turbine projects are under construction that should increase Maine's wind size by 103.8 MW. A breakdown of these projects is included in the table below.

Wind Turbine Farms in Maine, September 2011[xlvii]

Location/Name of Wind Turbine Farm	# of Wind Turbines	Individual Wind Turbine Capacity	Size of Wind Turbine Farm	Year Operational
Mars Hills	28	1.5 MW	42 MW	2007

Beaver Ridge	3	1.5 MW	4.5 MW	2008
Stetson Ridge	38	1.5 MW	57 MW	2009
Vinalhaven Island (Fox Islands Wind Project)	3	1.5 MW	4.5 MW	2009
Kibby Mountain	44	3.0 MW	132 MW	2009 - 2010
Stetson Ridge II	17	1.5 MW	25.5 MW	2010
Rollins	40	1.5 MW	60 MW	2011
Kibby Mountain Expansion	*11*	*3.0 MW*	*33 MW*	*Permit approved in 2011, under construction*
Oakfield	*50*	*3.0 MW*	*150 MW*	*Permit under review*
Highland	*39*	*2.3 – 3.0 MW*	*90 – 117 MW*	*Permit rescinded by applicant in 2011, but may be resubmitted in the future to DEP*
Record Hill	*22*	*2.3 MW*	*50.6 MW*	*Under construction*
Black Mountain	*19*		*40 MW*	*Under consideration*
Spruce Mountain	*10*	*2.0 MW*	*20 MW*	*Under construction*
Saddleback Ridge	*12*	*2.75 MW*	*33 MW*	*Permit under review*
Bowers Mountain	*27*	*2.3 – 3.0 MW*	*69 MW*	*Permit under review*
Bull Hill	*19*	*1.8 MW*	*34.6 MW*	*Permit under review*
Total Operational in Maine	173		325.5 MW	

Wind projects have encountered some resistance in Maine, with some of the concerns raised being health issues, especially related to the noise. Neighbors of the Mars Hill, Beaver Ridge, and Vinalhaven Island projects have especially voiced noise concerns.

The Mars Hill Mountain project is located along a very hilly ridge that includes a ski area in the town of Mars Hill, Maine. This was the first large-scale wind project in Maine,

and was given a 5 dBA variance to noise limits by Maine DEP, thus allowing 50 dBA at nighttime. Several homes are located within about 1,200 – 1,500 feet of the turbines, and some of these residents have complained about a variety of health issues associated with the turbines.[xlviii]

The Beaver Ridge project in Freedom, Maine, consists of 3 turbines with some nearby residences within about 1,000 feet. This project was exempt from state noise regulations because state law at the time did not require such permits from projects with small land footprints (< 3 acres), and the town did not have an ordinance in place with applicable noise requirements. As a result of neighbors' concerns, the turbines have been adjusted and some have had their property purchased by the developer. However, concerns remain.[xlix]

Fox Islands Wind Project is the East Coast's largest community wind project. Located on Vinalhaven Island, about 12 miles off Maine's mid coast, Fox Islands Wind was started by a cooperative made up of community members from the neighboring islands of Vinalhaven and North Haven as a way to provide sustainable lower cost electricity. After several years of planning, in July 2008, the ratepayers voted 382 to 5 to move forward with the proposed wind power project. Fifteen months later, the project became operational on a granite ledge about 180 feet above sea level.[l]

The site of the Fox Island Wind Project has 3 turbines with some 12 residences located within 1,200 to 3,000 feet, with 5 of these within 1,200 to 2,000 feet. Several of these home owners have raised health concerns related to the noise generated by the turbines.[li] As a result, measurements were made, the turbines were found not to be in full compliance with the 45 dBA nighttime cap, and adjustments have been made, though some concerns persist.[lii] Despite these concerns, a 2010 survey among 515 islanders indicated strong support. 99% said they support wind energy, and 95% said they are either more supportive or have unchanged views of the Fox Island Wind Project since it became operational. The project has been put forth as a model for financing and community sustainability and engagement.[liii] [liv]

The nighttime noise cap of 45 dBA has appeared to many in Maine DEP's 2009-2010 leadership to be successful, and they note that there are few complaints about noise from wind projects that are and have been in full compliance with the state cap of 45 dBA. All three projects with the most widely-known objections at some point have not been in compliance with the 45 dBA state cap: Mars Hill was granted a 5 dBA variance to 50 dBA; Beaver Ridge was exempt from state noise regulations at the time of its development becaue of its small (< 3 acre) footprint; and Vinalhaven was found to be non-compliant with the 45 dBA cap in 2010.[lv]

Although Maine communities do not normally need to approve a wind project, because of Home Rule, they are able to pass ordinances that put restrictions on wind development stricter than those found in state statute. As a result of concerns, especially about noise levels and related health issues emanating from the above three wind projects, some municipalities have passed ordinances with stricter noise limits than state statute or put a

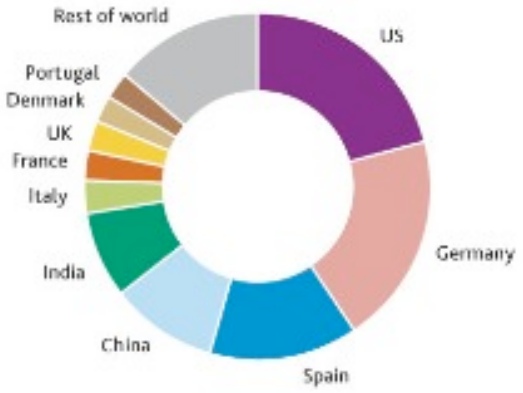
moratorium on such development. Some of these stricter noise limits or setback requirements from residences effectively halt wind power development.

Additionally, as a result of concerns raised among some Mainers about wind turbine noise-related health issues, a citizen-initiated proposal was brought before the Maine Board of Environmental Protection in 2011 to reduce the allowable noise cap and make other changes related to the measurement of turbine noise. In September 2011, Maine BEP provisionally adoped a rule to reduce the nighttime cap from 45 dBA to 42 dBA as well as make other changes related to measuring turbine noise. Adoption of these rules will be determined by the Legislature in 2012.[lvi]

APPENDIX

GLOBAL STATUS OF WIND POWER

TOP 10 TOTAL INSTALLED CAPACITY 2008



	MW	%
USA	25,170	20.8
Germany	23,903	19.8
Spain	16,754	13.9
China	12,210	10.1
India	9,645	8.0
Italy	3,736	3.1
France	3,404	2.8
UK	3,241	2.7
Denmark	3,180	2.6
Portugal	2,862	2.4
Rest of world	16,693	13.8
Total top 10	**104,104**	**86.2**
World total	**120,798**	**100.0**

lvii

CO2 emissions per capita in tons of CO2 (2007 data) followed by emission changes from 1990 to 2007:[lviii]

Sweden:	5.1	-12.4
USA:	19.1	18.6
Denmark:	9.2	0.2
Australia	18.8	52.5
U.K.	8.6	-5.4

Energy use, kWh per capita, 2008:[lix]

USA:	87,216
European Union:	40,821

U.S. STATUS OF WIND POWER

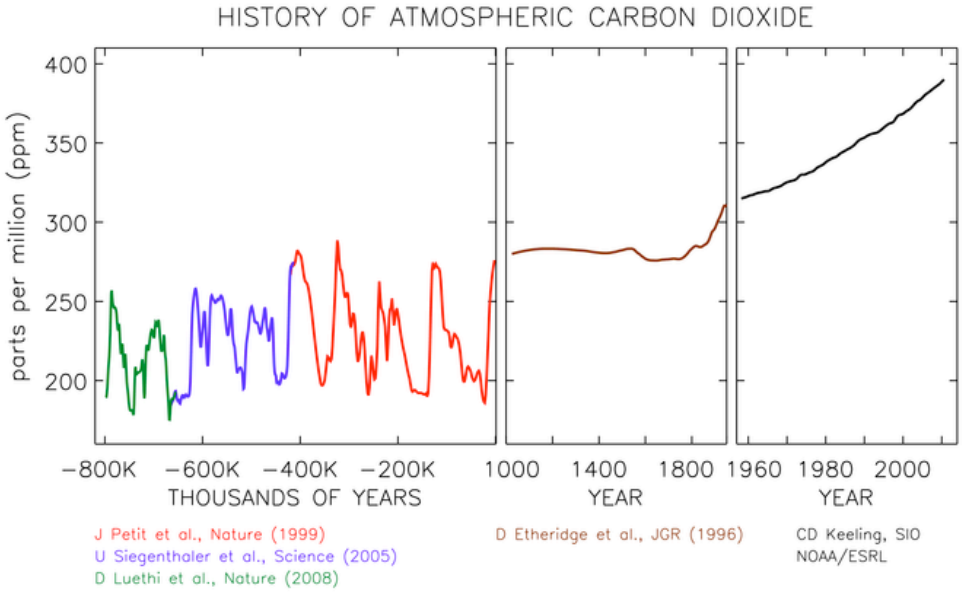
Wind power generation now in 38 US states

38 states now have utility-scale wind projects, and 14 states have now installed more than 1,000 MW of wind power. The top five states for cumulative wind energy capacity at the end of 2010 were Texas (with 10,085 MW installed), Iowa (3,675 MW), California (3,177 MW), Minnesota (2,192 MW), Oregon and Washington State (both 2,104 MW). All these states have ambitious renewable energy targets in place, and some of them now generate considerable shares of their electricity needs from wind power. In Iowa, for example, wind power provides close to 20% of the total power consumption, while Texas now generates 7.8% of its electricity with wind, more than in Germany.

Other US states active in pursuing targets for renewable energy during 2010 were Illinois (498 MW added in 2010),

California (455 MW), South Dakota (396 MW) and Minnesota (396 MW). Other states, such as Delaware, Maryland, Idaho, South Dakota and Arizona, got a late start in wind power development but are now growing rapidly. [lx]

HISTORY OF ATMOSPHERIC CARBON DIOXIDE



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