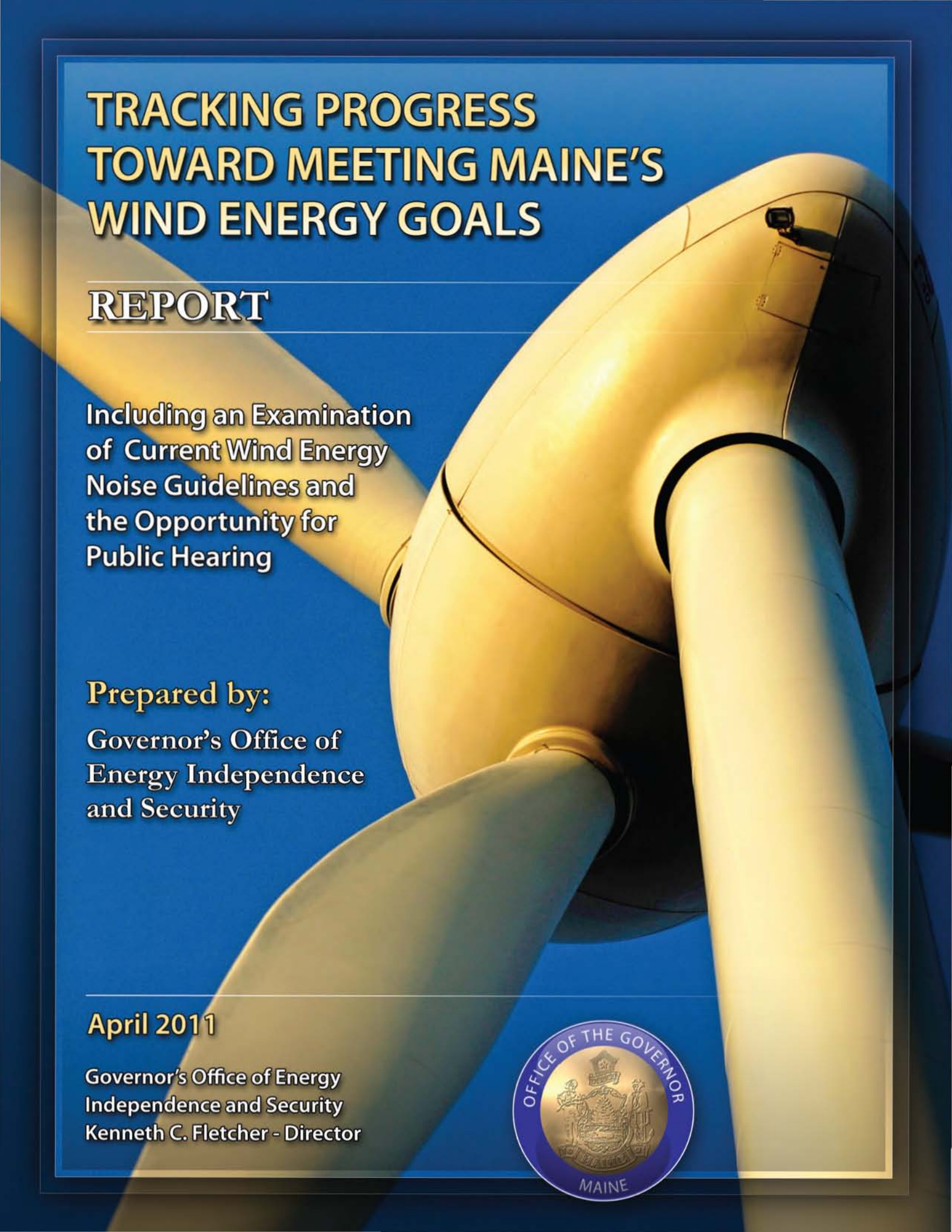
TRACKING PROGRESS TOWARD MEETING MAINE'S WIND ENERGY GOALS

REPORT

Including an Examination of Current Wind Energy Noise Guidelines and the Opportunity for Public Hearing



Prepared by:

Governor's Office of Energy Independence and Security

April 2011

Governor's Office of Energy Independence and Security
Kenneth C. Fletcher - Director

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A. Tracking Progress Toward Meeting Maine's Wind Energy Goals

As required by *The Wind Energy Development Act*, enacted as Public Law 2007, Chapter 661, the Governor's Office of Energy Independence and Security (OEIS) is responsible for reporting to the Joint Standing Committee on Utilities, Energy and Technology on the "**State of Maine's wind energy goals and realization of tangible benefits"** by January 15th of each year. In addition, by December 2013, the OEIS is responsible, in consultation with other state agencies as appropriate, for conducting a full review of the status of meeting the goals for 2015 and the likelihood of achieving the goals for 2020.

The OEIS has been monitoring the progress and has made an assessment of the State's progress toward meeting the wind energy development goals established in the Maine Revised Statutes, Title 35-A, section 3404, subsection 2 and the realization of the tangible benefits of wind energy developments as well as other considerations and pertinent questions included in the law.

According to the statute, (Part C was added in 2010) the goals for wind energy development in the State are that there be:

> A. At least 2,000 MW of installed capacity by 2015; and
> B. At least 3,000 MW of installed capacity by 2020, including 300 MW or more from generation facilities located in coastal waters, or in proximate federal waters; and
> C. At least 8,000 MW of installed capacity by 2030, including 5,000 MW from generation facilities located in coastal waters or in proximate federal waters.

To accomplish the above task, the OEIS has conferred with both the Department of Environmental Protection (DEP) and the Land Use Regulation Commission (LURC), the State's two permitting and regulatory entities responsible for permitting wind energy projects. The OEIS has also met with and had discussions with wind energy developers and members of the public to gauge process and progress of wind energy development in the State.

I. Assessment of Progress Toward Meeting Wind Energy Development Goals

Currently, a total of six large-scale wind energy development projects are operating in the State of Maine with a total capacity of 265.5 MW. In addition, there are two large-scale wind energy development projects under construction with a potential total of 115 MW of capacity, three projects that have been permitted (although two projects have been appealed) with a potential of 102 MW and at least seven wind energy projects under development with the total potential capacity of 533.50 MW. Other projects are in

discussion or appear in ISO-NE's queue but are not far along enough to be counted by either the DEP or LURC as a serious project at this time. There are no off-shore wind projects in operation or under development in Maine at this time.

Summary of Progress Toward Meeting Wind Energy Development Goals

- The State of Maine has met 13.28 % of wind energy goals with 265.5 MW of installed capacity. (Based on the 2015 goal.)
- The percentage would rise to 19.3 % if all 115 MW of capacity under construction are operational.
- The percentage would rise to 24.4 % if all 102 MW permitted are constructed and operational.
- The percentage would rise to 50.55 % if all 528.5 MW in development are constructed and operational.

Summary of Wind Energy Development Projects in Maine

6 Large-Scale Wind Energy Projects in Operation

Mars Hill, (First Wind) - 42 MW
Freedom, (Beaver Ridge) – 4.5 MW
Stetson I, (First Wind) – 57 MW
Kibby Mtn. (TransCanada) 132 MW
Vinalhaven Island, (Fox Islands, LLC) – 4.5 MW
Stetson II, (First Wind) – 25.5 MW
Total Operational: 265.5 MW

2 Large-Scale Wind Energy Projects Under Construction:

Rollins Mtn., (First Wind) – 60 MW
Record Hill/Roxbury, (Independence) – 55 MW
Total Under Construction: 115 MW

3 Large-Scale Wind Energy Projects Permitted:

Oakfield, (First Wind) – 51 MW (approved & appealed, appealed to ME law court)
Spruce Mtn., (Patriot Renewables) – 18 MW (appealed)
Kibby Phase II, (TransCanada) – 33 MW
Total Permitted: 102 MW

7 Large-Scale Wind Energy Projects Under Development:

Longfellow/Rumford/Roxbury (Black Mtn.) – (First Wind) – 50 MW
Number Nine Horizon - (Horizon/Aroostook Wind) – 200 MW
Highland Wind, LLC (Independence) – 126.8 MW
Saddleback Ridge, (Patriot Renewables) – 34.5 MW
Col. Holman Mtn./Dixfield, (Patriot Renewables) – 26 MW
Bowers Mtn. – (First Wind) – 57 MW
Bull Hill – (First Wind) – 34.2 MW
Total Under Development: 528.5 MW

Offshore Wind Energy Development

Based on the efforts of the Governor's Ocean Energy Task Force (OETF) and its final report, two major pieces of legislation were passed in 2009 and 2010 related to offshore wind energy development. The OETF's focus and Maine's primary interest has been on deep-water ocean wind energy projects, turbines that will be placed in deep water off the Outer Continental Shelf (OCS). This geographic focus was driven by a number of factors, including the availability of a vast and renewable energy source, a need to move home heating and transportation costs away from volatile gas fluctuations, a desire to move wind turbines offshore, the creation of unique industrial, technical, and specialized jobs, and the possibility of energy exportation. Maine's coastal waters feature heavily-used fishing grounds and widely acknowledged scenic qualities. There is a general agreement that well-sited development in federal waters ten miles or more off the coast will have less of a potential for adverse effects on fishing activity as well scenic and other natural resources. In addition, increased energy security, stabilized energy prices and reduced electricity costs for Maine ratepayers and businesses are significant goals for off-shore wind development.

LD 1465, "An Act To Facilitate Testing and Demonstration of Renewable Ocean Energy Technology", enacted as Public Law 2009, Chapter 270, facilitates the research, development, and testing of renewable ocean energy technologies in state-designated demonstration and testing areas. It provides for the issuance of a time-limited, general permit for ocean energy projects from the Department of Environmental Protection for any development located within these areas. In December 2009, the State designated three testing and demonstration sites in state waters off Boon Island, Damariscove Island, and Monhegan Island. The Monhegan Island site has been designated to advance the University of Maine's research and development activities regarding deep-water offshore wind technologies and other forms of renewable ocean energy.

LD 1810 "An Act to Implement the Recommendations of the Governor's Ocean Energy Task Force", enacted as Public Law 2010, Chapter 615, clarifies and streamlines the permitting and leasing processes for renewable ocean energy projects. It also

increased the State's wind energy goals to a total of 8 GW, including 5 GW of offshore wind energy, which the OETF deemed commensurate with the potential of deep-water wind energy resources in the Gulf of Maine and well-aligned with national wind energy goals. The law also directed the Maine Public Utilities Commission (MPUC) to issue a competitive solicitation in the fall of 2009 for a long-term contract for up to 25 MW of deep-water wind energy and 5 MW of tidal power, subject to a statutorily-set price cap.

The State is currently working with Federal agencies and other Atlantic states to further the development of offshore wind energy development off the coast of Maine. Maine is a participant in the Atlantic Offshore Wind Energy Consortium (AOWEC) formalized by a Memorandum of Understanding signed by Secretary of Interior Salazar with the ten member states on June 8, 2010. The AOWEC was initiated by the Department of the Interior (DOI) to facilitate the expeditious development of the wind resources of the OCS in a safe, responsible, and environmentally sound manner and to improve the working relationships and facilitate coordination among the participants on regional issues of mutual interest relating to wind development on the Atlantic OCS.

Maine proposed and received the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement's (BOEMRE), (formerly Minerals Management Service) conceptual endorsement of a "Maine Pilot Pioneer Project", which will model a streamlined, three-year process for completing the National Environmental Policy Act (NEPA) and all other applicable environmental reviews and issue requisite approvals for siting a 25 MW deep-water wind technology testing project in federal waters 10 or more miles off Maine's coast in accordance with geographic criteria in the MPUC's above-noted competitive solicitation. DOI has included the Maine pilot in AOWEC's draft work plan, finalization of which is expected in the first quarter of 2011.

In June 2010, Governor Baldacci requested BOEMRE to form a federal-state task force, as it has in other East Coast states, to discuss issues and options and lay groundwork for well-coordinated federal-state review of any proposed leasing of federal OCS areas off Maine for wind energy development. This BOEMRE-State task force, which met twice in 2010, is a consultative, inter-governmental group of public officials comprised of Federal, state, local, and tribal representatives. The purpose of the task force is to assist government decision-making regarding renewable energy leasing and development on the OCS off the coast of Maine. Based on the limited information currently available, the State Planning Office has identified several OCS areas that appear to merit further consideration and discussion by the task force as potentially suitable for deep-water ocean energy development. For more information go to:
http://www.maine.gov/spo/specialprojects/renewableoceanenergy/faq.htm

II. Examination of Experiences from the Permitting Process

The OEIS, in conversations with both regulators and developers has found that overall the Wind Power Development Act is working as intended. However, with the increased numbers of operational and proposed wind energy developments, public controversy and opposition to wind energy continues and appeals have lengthened the permitting process considerably. In Part B of this report, OEIS makes some specific recommendations related to the State's noise regulations that may help curb some of the opposition and appeals to wind energy development projects in the future.

Progress on Permitting in LURC's Jurisdiction

LD 1680, "An Act to Assist in Reviewing Wind Energy Applications" enacted as Public Law 2010, Chapter 492, was intended to create consistency in the application and permitting process of wind energy developments before LURC and DEP. The law requires LURC to render a determination on an application in the expedited permitting area for projects 100 kW or greater within 185 days after the LURC determines that the application is complete, except the LURC can render a decision in 270 days if a public hearing is held. These timeframes are consistent with DEP's.

LD 1504, "An Act to Provide Predictable Benefits to Maine Communities That Host Wind Energy Developments", enacted as Public Law 2010, Chapter 642, changed appeals of final actions of the LURC for expedited wind energy developments to the Supreme Judicial Court sitting as the Law Court. The Law Court now has exclusive jurisdiction over requests for judicial review of final actions of the LURC regarding expedited wind energy developments.

Progress on Permitting in DEP's Jurisdiction

LD 1504, "An Act to Provide Predictable Benefits to Maine Communities That Host Wind Energy Developments", also changed the judicial appeal of final action by the DEP or DEP Commissioner regarding an application for expedited wind energy development. Now appeals are to be taken to the Supreme Judicial Court sitting as the Law Court. The Law Court now has exclusive jurisdiction over requests for judicial review of final action by the Commissioner or DEP regarding expedited wind energy developments.

III. Identified Successes, Including Tangible Benefits, in Implementing the Recommendations in the Final Report of the Governor's Task Force on Wind Power Development in Maine pursuant to the Executive Order issued May 8, 2007

The successes that OEIS has identified over the last year in implementing the recommendations contained in the Governor's Task Force on Wind Power Development in Maine include the following:

- Maine continues to gain ground in meeting the State's wind energy development goals with a total installed wind energy capacity of 265.5 MW.

- Maine continues to be a leader in wind power development in New England and the nation.
- Maine continues to protect Maine's quality of place and natural resources as projects are developed.
- Significant meaningful tangible benefits are being delivered to the economy, environment, and Maine people.
- Considerable progress was made on the potential development of deep-water off-shore wind energy through the Governor's OETF and legislation to designate research and testing sites off the coast of Maine as well as streamlined permitting of offshore wind energy facilities.

IV. Projections of Wind Energy Developers' Plans and Their State Policy Implications

There has been much interest in developing wind energy development projects in Maine due to the excellent wind resources, potential development of transmission, many operational wind energy projects and interest in renewable energy generation and reduction of greenhouse gas emissions. There are numerous wind energy projects currently in development and others in the discussion phase. However, the continuing economic recession, somewhat lower petroleum prices (although recently they have increased) and the credit crunch, as well as growing local opposition to projects have some developers scrambling for financing, fighting lengthy appeals and potentially re-thinking plans for new projects and/or looking to states where existing transmission lines or lower project costs may exist.

V. Technology Trends

All operational wind energy development projects in Maine use General Electric (GE) 1.5 MW turbines with the exception of the Kibby project which operates 3 MW Vestas turbines. Developers are looking to new turbine designs that are now coming to market. For example, Independence Wind has recently said they are investigating the use of GE 2.5 MW, Siemens 2.3 MW and 3 MW turbines. Other developers are considering new models as they become available in the marketplace and are proposed for a number of projects in Maine. Following are brief descriptions of the existing and new turbine models.

General Electric 1.5 MW Turbine

According to GE the 1.5 MW turbine "is active yaw and pitch regulated with power/torque control capability and an asynchronous generator. It uses a bedplate drive train design where all nacelle components are joined on a common structure, providing exceptional durability. The generator and gearbox are supported by elastomeric elements to minimize noise emissions." There are over 14,000 units of these turbines in operation worldwide and it continues to be one of the world's most widely used wind turbines in its class.

GE 2.5 MW Turbine
According to GE, their 2.5 MW turbines "can be deployed on over 85% of the sites being developed today. The turbine generates a leading amount of annual energy production and its 100m rotor also makes it an excellent solution for low wind sites. The patented rotor blade technology provides the turbine with very competitive acoustic performance. With the optional noise-reduced operation modes, the turbine can be deployed at sites with the most stringent noise restraints, while simultaneously maintaining a high energy yield. The turbine can also be equipped with various towers resulting in hub heights of 100m, 85m and 75m, meeting potential tip height constraints and maximizing energy yield."

GE 2.75 MW Turbine
The Saddleback Ridge project is proposing to use this turbine. According to Windpower Engineering, GE's 2.75-100, turbine was announced in September, 2010 and "is an uprate of the existing 2.5-100 wind turbine without mechanical component changes and only minor changes to the electrical system. GE's 2.75-103, a combination of the 2.75 uprate and the 103-m rotor which uses GE's 50.2 m proprietary blade design offers the latest enhancements in aerodynamics, reduced acoustics, and robust performance".

Gamesa 2 MW Turbine
The Spruce Mountain project is proposing to use this turbine. According to RenewableEnergyfocus.com the G9X model was announced in September, 2010 and is designed for sites with low wind resources, is produced with lighter blades using fiberglass and prepreg method and has an aerodynamic design NRS control system to minimize noise emissions.

Vestas V90 3 MW Turbine
According to Cleantech, "the V90 wind turbine consists of a rotor in a total diameter of 90 meters. The rotor has a swept area of 6,362 square meters with a total of three blades. It operates at a speed of 16.1 rotations per minute. The turbine can be installed on towers with varying hub heights such as 80 meters and 105 meters. The V90 wind turbine generates 3 megawatts of power at a nominal wind speed of 15 meters per second. The cut-in and cut-out wind speeds of the turbine are 4 meters per second and 25 meters per second, respectively".

Siemens 2.3 MW Turbines
The Siemens 2.3 MW turbine unit is among the largest land-based turbines deployed in the U.S. According to WindPower Engineering it was "turbine of the month" in March, 2010 and is currently being tested at the National Renewable Energy Lab's Technology Center. Testing is examining "structural and performance characteristics, aerodynamic and performance improvements, along with model, acoustics, and power-quality studies.

The turbine is fitted with a 101-m diameter rotor (331 ft) and mounted atop an 80-m tower (262 ft)".

Siemens 3 MW Turbines

The Siemens 3 MW turbine was announced for sale in April, 2010 and according to Siemens, "offers innovation through a completely new Direct Drive concept introducing a permanent magnet generator. With half the parts of a conventional geared wind turbine, and much less than half the number of moving parts, the new wind turbine will require less maintenance and increase profitability for customers. The new Direct Drive wind turbine features a rotor diameter of 101 meters and is now available for sale for onshore and offshore projects around the world. The main advantage of permanent magnet generators is their simple and robust design that requires no excitation power, slip rings or excitation control systems. This leads to high efficiency even at low loads. A major advantage of the new machine is its compact design. With a length of 6.8 meters and a diameter of only 4.2 meters, the nacelle can be transported using standard vehicles commonly available in most major markets."

Off-shore wind energy turbine development technologies are just emerging and it remains to be seen which technologies will prove to be commercially viable.

VI. Maine and New England States' Progress Toward Reducing Greenhouse Gas Emissions

The 121st Maine State Legislature passed, and Governor Baldacci signed into law, L.D. 845, "An Act to Provide Leadership in Addressing the Threat of Climate Change" enacted as Public Law 2003, Chapter 237. The Act set goals for the reduction of greenhouse gas emissions within the state, adopting similar targets previously proposed by the New England Governors/Eastern Canadian Premiers conference in 2001, signed by then-Governor King, and subsequently endorsed by Governor Baldacci. These call for a reduction of greenhouse gas emissions to 1990 levels by 2010, to 10% below 1990 levels by 2020, and in the long term, potential reductions sufficient to eliminate any dangerous threat to the climate which could be as much as 75% to 80% below 2003 levels.

The Maine DEP bi-annually tracks and reports to the Environment and Natural Resources Committee the progress the State of Maine is making toward reducing greenhouse gas emissions. The 2010 biannual report was submitted in 2010. The report can be accessed here:
http://www.maine.gov/dep/air/greenhouse/pdf/Third%20Biennial%20Report%20FINAL%20ALL%20PAGES%20CORRECTED%2002192010.pdf.

The DEP's report includes the results of EPA's state inventory tools to estimate Maine's greenhouse gas emissions for 1990-2008. It includes an analysis of data looking at trends

and examples showing that economy-wide greenhouse gas emissions peaked in 2003 and have been showing an overall downward trend. The report also discusses the policies and programs believed to contribute to those trends. Finally, it addresses how the State is to meet its next target in 2020.

Greenhouse gas emissions data for each New England state from the Northeast States for Coordinated Air Use Management (NESCAUM) is attached. See: Attachment #1.

VII. OEIS Recommendations on Permitting

OEIS' recommendations on potential changes to the State's wind energy development regulations are included in Part B of this report.

VIII. Tangible Benefits

Prior to July 12, 2010 grid-scale, commercial wind energy projects proposed in the State of Maine had to provide "significant tangible benefits". In making findings, the primary siting authority (DEP/LURC) had to presume that an expedited wind energy development provided energy and emissions-related benefits and had to make additional findings regarding other tangible benefits provided by the development.

"Tangible benefits" was defined as environmental or economic improvements attributable to the construction, operation and maintenance of an expedited wind energy development, including but not limited to: construction-related employment; local purchase of materials; employment in operations and maintenance; reduced property taxes; reduced electrical rates; natural resource conservation; performance of construction, operations and maintenance activities by trained, qualified and licensed workers in accordance with Title 32, chapter 17 and other applicable laws; or other comparable benefits, with particular attention to assurance of such benefits to the host community to the extent practicable and affected neighboring communities.

New Tangible Benefits Requirements

LD 1504, "An Act to Provide Predictable Benefits to Maine Communities That Host Wind Energy Developments", enacted as Public Law 2010, Chapter 642 signed into law effective July 12, 2010 changed the definition of "tangible benefits". Tangible benefits now also include property tax payments resulting from the development and other payments to a host community, including, but not limited to payments under a community benefit agreement. Tangible benefits also apply to host communities instead of just one community.

Community Benefit Agreement

"Community benefit agreement" is defined as an agreement between the developer of an expedited wind energy development and a host community that involves payments by the developer to the host community to be utilized for public purposes including, but not

limited to property tax reductions, economic development projects, land and natural resource conservation, tourism promotion or reduction of energy costs, and specifies in writing the value of the payments to the community and any payment schedule and other terms and conditions made over time by the developer to the host community.

Community Benefits Package
"Community benefits package" is defined as the aggregate collection of tangible benefits resulting from: payments, not including property tax payments, to the host community or communities including, but not limited to, payments under community benefit agreements, payments that reduce energy costs in the host communities and any donations for land or natural resource conservation. An applicant for a wind energy development is required to establish a community benefits package valued at no less than $4,000 per year per wind turbine, averaged over a 20-year period, unless a host community's legislative body votes to waive or reduce the community benefits package requirement. Projects under 20 MW in size, owned by a nonprofit entity or quasi-public entity, or are located on certain Indian territories are exempt from this requirement.

Tangible Benefits Required Documentation
Wind energy permit applications must now include the following information regarding tangible benefits:

- Estimated jobs to be created statewide and in host communities as a result of construction, maintenance and operations;
- Estimated annual generation of wind energy;
- Projected property tax payments;
- Description of the community benefits package, including but not limited to community benefit agreement payments; and
- Any other tangible benefits to be provided by the project.

The law also expanded the reporting of tangible benefits by the OEIS by adding a summary of tangible benefits provided by expedited wind energy developments including but not limited to, documentation of community benefits packages, community benefit agreement payments provided, as well as a review of the community benefits package and the actual amount of negotiated community benefits packages relative to the statutorily required minimum amount.

IX. Tangible Benefits Reporting

Three wind energy projects fall under the original tangible benefits reporting law during the time period of this annual report. These include the Kibby II, Spruce Mountain and Saddleback projects.

Two wind energy projects fall under the amended tangible benefits reporting law during the time period of this annual report. These include the Bull Hill and Highland wind energy development projects. The amended law allows for information on the community benefits package to be submitted as an addendum during the period in which the application is pending. Both Bull Hill and Highland wind projects are still pending before the LURC as of the development of this report. It is possible that additional information may be submitted on the Bull Hill project and additional information is expected to be submitted from the developer on the Highland project as part of the community benefits package.

Therefore, OEIS is not able at this time to provide the additional reporting details mentioned above other than the summaries of the tangible benefits as the applications are not final. Once the applications are final and permits are issued, OEIS will obtain copies of the necessary community benefit package agreements, community benefit payments and will perform on-going reviews of the community benefit packages relative to the statutory required minimum amount of $4,000 per turbine per year.

Summary of Tangible Benefits

Spruce Mountain Tangible Benefits
The Spruce Mountain project is being developed by Patriot Renewables. It received its permit from DEP in October 2010. See attachment #2 for the tangible benefits associated with this project.

Saddleback Ridge Tangible Benefits
The Saddleback Ridge project is being developed by Patriot Renewables. Its application was accepted as complete for processing from DEP in November, 2010. See attachment #3 for the tangible benefits associated with this project.

Kibby II
The Kibby II project is being developed by TransCanada. It received its permit from LURC on January 5, 2011. See attachment #4 for the tangible benefits associated with this project.

Bull Hill
The Bull Hill project is being developed by First Wind. Its application is currently being reviewed by the LURC for completeness. See attachment #5 for the tangible benefits associated with this project. This project is subject to the amended tangible benefits reporting requirements mentioned earlier.

Highlights of the Bull Hill project's tangible benefits include the following:

Total project cost: $78.5 million

- Estimated jobs created as a result of construction: 65 full-time equivalents employing 225 individuals
- Maintenance and operations jobs: 3-8 permanent jobs
- Estimated annual generation of wind energy: 94,000 MW/hours per year
- Projected property tax payments: $342,343 annually over 20-years
- Community benefits package: $4,000 per turbine per year over 20 years, $30,000 to the town of Eastbrook annually and $10,000 annually for water quality improvements.

Highland Wind Tangible Benefits

The Highland Wind project is being developed by Independence Wind. Its application is currently being reviewed by the LURC for completeness and additional information will be added to the Community Benefits Package. This project is subject to the amended tangible benefits reporting requirements mentioned earlier. See attachment #6 for the tangible benefits associated with this project.

Highlights of Highland Wind project's tangible benefits include the following:

Total project cost: $210-247 million

- Estimated jobs created as a result of construction: 330 full-time jobs at peak construction
- Maintenance and operations jobs: 8 permanent jobs
- Estimated annual generation of wind energy: Approximately 306,000 MW/hours per year
- Projected property tax payments: $118,000-$526,000 year depending on assessment
- Community benefits package: $4,000 per turbine per year over 20 years for a total of $3,120,000, 20 annual payments of $104,000 to Highland Plantation for energy conservation, $1,040,000 to the Maine Department of Conservation and Bureau of Public Lands (BPL) over 20 years for land conservation and 20 annual payments of $39,350 to the BPL for the Bigelow Preserve.

Community Benefits Package Requirement Recommendations

Because neither project that is required to adhere to the new tangible benefits requirements has completed their negotiations or finalized their community benefits packages, it is premature for OEIS to make recommendations at this time. However, it is clear from the two draft applications received by the State so far that generous community benefits packages are being negotiated with local communities.

B. Examination of Noise Regulations and Opportunity for Public Hearing

I. Introduction

With the development of grid-scale wind energy in Maine, there has been a growing discourse about whether noise regulations and the regulatory process for permitting wind energy projects, specifically, the potential for a public hearing as part of that process, are adequate or should be refined.

As a result, on February 23, 2010 the Standing Committee on Utilities and Energy wrote John Kerry, Director of the Governor's Office of Energy Independence and Security (OEIS) directing the OEIS to examine these two issues as part of its annual report "Tracking Progress Toward Meeting Maine's Wind Energy Goals" regarding tangible benefits and potential recommendations to the existing wind energy development permitting process. OEIS currently does not have any regulatory or review authority over permitting of wind energy or any other type of industrial projects.

OEIS consulted with the following parties, who provided their input gratis, in order to gather information to inform our research process.

- Jeremy Payne, Director, Maine Renewable Energy Association
- Rufus Brown, Attorney at Law
- Dr. Monique Aniel, M.D.
- Sue Jones, President, Community Energy Partners
- Dr. Dora Mills, Director, Maine Centers for Disease Control (until January 3, 2010)
- Warren Brown, EnRad Sound Consulting, Consultant for Maine Department of Environmental Protection (DEP) and Maine Land Use Regulation Commission (LURC)
- Eric Lantz, National Renewable Energy Lab

OEIS met with DEP and LURC staff and Dr. Dora Mills to discuss the current noise regulations. Staff from both agencies and Dr. Mills reviewed this report for accuracy. OEIS asked Jeremy Payne, Sue Jones, Dr. Aniel and Rufus Brown to review this report and make written comments prior to its submission to the Utilities, Energy and Technology Committee. Comments from these four folks are either attached to this report or will be submitted directly to the Committee.

OEIS also reviewed an extensive bibliography of information on the two subjects. See bibliography.

Through extensive research and discussions with knowledgeable people, OEIS has found that the topic of sound, and regulation of wind turbine noise in particular, to be a highly technical, complex and complicated subject. We have attempted to simplify and summarize this complexity for the general reader. Therefore, we have included in this examination background information on various related topics so as to educate our readers to a basic level of knowledge in order for productive discourse on the subject to occur. OEIS did not assert it had all the answers at the beginning of the process, nor do we believe we are experts on the subject at this time. However, we have completed a thorough examination of the issues and have come to some conclusions and provided recommendations that may be helpful in guiding policymakers in Maine to improve the process relating to the permitting of wind energy development and modifications to the current noise regulations.

II. The Basics of Sound

Sound is defined as a rapid pressure fluctuation above and below the static atmospheric pressure. These small-scale pressure fluctuations produce sensations in the human ear. [1] Noise is typically defined as unwanted sound.

Figure 1. Sound

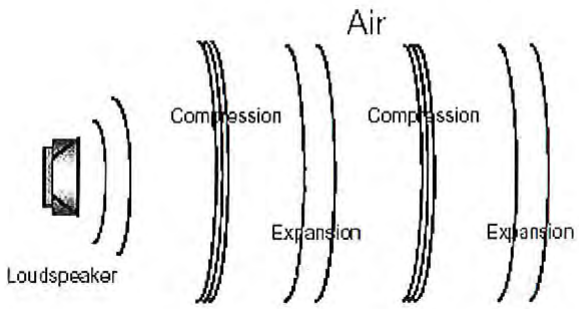


Figure 1: Sound (Source: Lawrence Technological University)

Sound Terminology

"The *frequency* is the number of times per second, or *Hertz* (Hz), the cycle of air compression repeats." Hertz are used to quantify the tonality, the base or treble of a sound.[2] "An *Octave* is a range where the lowest frequency is exactly half the highest

[1]Alberts, Daniel J., "Primer for Addressing Wind Turbine Noise", Lawrence Technological University, October, 2006, Pg. 4

[2]Bastasch, Mark, Massachusetts Clean Energy Center, New England Wind Energy Education Program, webinar on Wind Turbine Noise, July 13, 2010

frequency. Sounds are often classified by the number of frequency components they contain. A *tone* is a sound that contains one frequency. Musical notes are tones. Mechanical systems often emit noise that contains a noticeable tone. *Narrowband* sounds contain two or more frequency components, but the frequencies are very close to each other, within 1/3 octave. *Broadband* sounds contain multiple frequency components, and the frequencies span more than 1/3 of an octave. Cars, lawn equipment, jet engines and wind turbines all produce broadband noise." [3]

Measurement Scales

In simplified terms, sound levels are measured in decibels (dBs). "A decibel is the logarithm of the ratio between two values of some characteristic quantity such as power, pressure or intensity, with a multiplying constant to give convenient numerical factors. Logarithms are useful for compressing a wide range of quantities, such as sound pressure, into a smaller range." [4] Typical sounds expressed in dBs include freeway traffic or trains, which heard from 50 feet may exceed 70 dBs. Interior sound levels are typically between 30 to 40 dBs. The typical audible range of a human ear extends from 20 hertz to 20,000 hertz.[5]

Below is a list of typical sound levels measured in dBs.

[3]Alberts, Daniel, Pg. 4

[4]Bellhouse, George, "Low Frequency Noise and Infrasound From Wind Turbine Generators: A Literature Review", prepared for Energy Efficiency and Conservation Authority, New Zealand, June 30, 2004, Pg. 4

[5]Bastasch, Mark, webinar

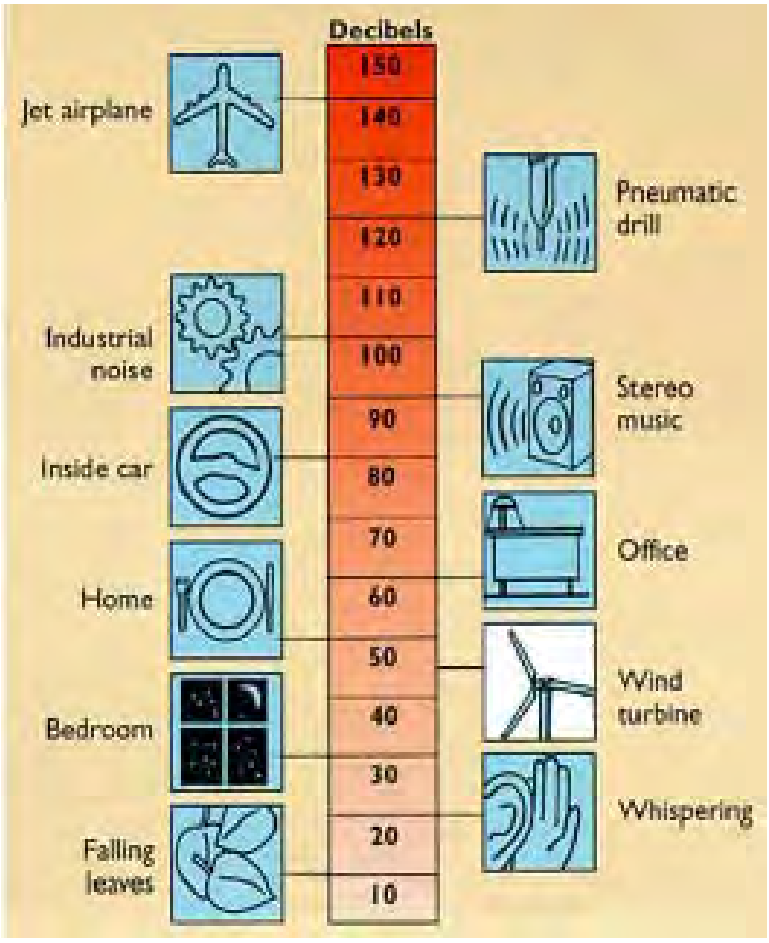


Figure 2: Chart of Typical Decibel Levels (Source: American Wind Energy Association)

Below are examples of outdoor Day-Night Average Sound levels measured at various locations:

Location	L_{dn} (dBA)
Apartment next to freeway	87
3/4 mile from runway at major airport	86
Downtown with construction activity	79
Old urban residential area	59
Wooded residential	52
Agricultural crop land	44
Rural residential	39
Wilderness ambient	35

Figure 3: Outdoor Day-Night Average Sound levels measured at various locations (Source: U.S. Environmental Protection Agency www.usepa.gov)

The above sound levels are averaged over 24-hours with an increase of 10 dBs between 10 p.m. and 7 a.m. to take into consideration lower levels of ambient background noise.

Sound Power and Sound Pressure

In order to "understand noise measurement and assessment, it is necessary to examine noise from an engineering perspective".[6]

"*Sound power* is the energy converted into sound by the source. Sound power is not measured directly, it is calculated from measurements, and is used to estimate how far sound will travel and to predict the sound levels at various distances from the source. As sound energy travels through the air, it creates a sound wave that exerts pressure on receivers such as an ear drum or microphone.

[6]Alberts, Daniel, Pg. 3

Sound Pressure is typically measured in micropascals and converted to a *sound pressure level* in decibels for reporting. Sound pressure level is used to determine loudness, noise exposure, and hazard assessment."[7] Sound pressure levels can also be described as a measure of the level at a receptor such as a neighbor, microphone, etc.[8]

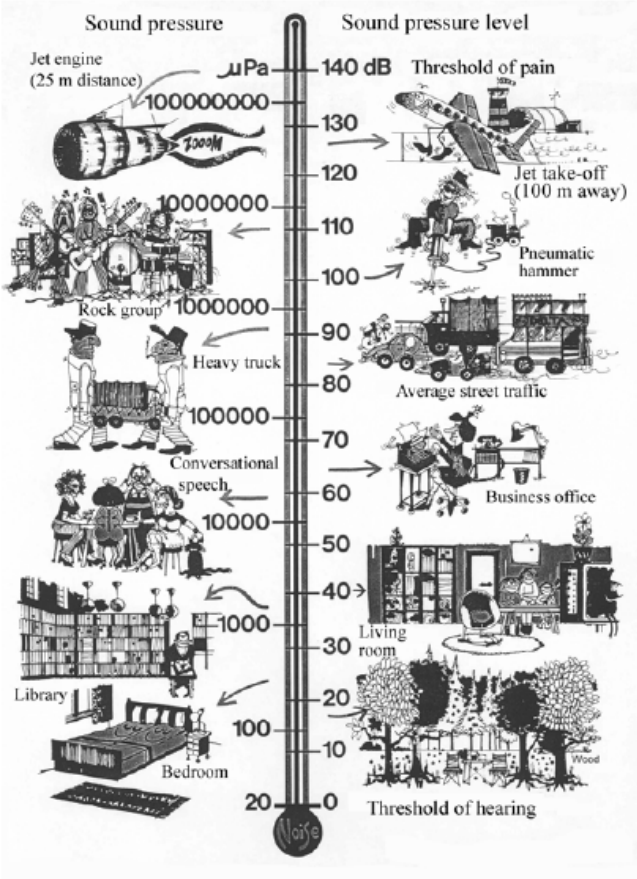


Figure 4: Sound Pressure Level Examples (Source: Bruel and Kjaer Instruments)

"Sound power and pressure levels are related quantities but it is important to note that a sound power level is independent of the distance of a source. It can be thought of as the wattage of a light bulb. Sound pressure level, what one hears or measures, varies with distance. The sound pressure level is used to quantify the sound emissions of a source and specify the distance such as 60 dBA measured at 100 feet.

[7]Alberts, Daniel Pg. 4
[8]Bastasch, Mark, webinar

Sound power and sound pressure levels cannot be compared. The sound power level takes into account the size of the source and is a calculated quantity. It is not appropriate to say a source of the sound power level of 120 dB and compare that level to a chart of sound pressure levels".[9]

Response to Sounds Measured in Decibels
The human response to sounds measured in decibels has the following characteristics:

- Except under laboratory conditions, a change in sound level of 1 dB cannot be perceived.
- Doubling the energy of a sound source corresponds to a 3 dB increase.
- Outside the laboratory, a 3 dB change in sound level is considered a barely discernible difference.
- A change in sound level of 5 dB will typically result in a noticeable community response.
- A 6 dB increase is equivalent to moving half the distance towards a sound source.
- A 10 dB increase is subjectively heard as an approximate doubling in loudness.
- The threshold of pain is a Sound Pressure Level of 140 dB.[10]

Noise Measurement Metrics
"Sound pressure levels are measured via the use of sound level meters. These devices use a microphone that converts pressure variations into a voltage signal which is then recorded on a meter (calibrated in decibels). The decibel scale is logarithmic. A sound level measurement that combines all frequencies into a single weighted reading is defined as a broadband sound level. For determination of the human ear's response to changes in sound, sound level meters are generally equipped with filters that give less weight to the lower frequencies.

Weighting Scale
There are a number of filters as described above:

- A-Weighting: This is the most common scale for assessing environmental and occupational noise. It approximates the response of the human ear to sounds of medium intensity.
- B-Weighting: this weighting is not commonly used. It approximates the ear for medium-loud sounds, around 70 dB.

[9]Bastasch, Mark, webinar
[10]Rogers, Anthony, James Manwell, and Sally Wright, "Wind Turbine Acoustic Noise, A White Paper", prepared for Renewable Energy Research Laboratory, Department of Mechanical and Industrial Engineering, University of Massachusetts, Amherst, June, 2002, amended in January, 2006, Pgs. 5-6

- C-Weighting: Approximates response of human ear to loud sounds. It can be used for low-frequency sound.
- G-Weighting: Designed for infrasound".[11]

"Many noise control texts state that the A scale is insufficient for determining the impact of noise or the level of annoyance when the frequency is below 100 Hz. Other texts state that the A scale is insufficient for any sound above 60 dB. These texts recommend the C scale which more closely resembles the actual sound pressure. However, the U.S. Department of Labor based their noise exposure standards on the A scale (along with a number of other government agencies including the World Health Organization) so it is likely that the A scale will remain predominant."[12]

In addition, "the G scale is used only for infrasound (sound below 20Hz). A few studies show that wind turbines do generate infrasound. However, the practicality and the importance of using the G scale for measuring this noise is still being debated". [13]
It should be noted that in addition to sound texts, many anti-wind advocates also claim that the A scale is not sufficient for determining adequate sound levels from wind turbines, particularly related to infrasound and low frequency sounds.

Averaging Time
"Each of the below metrics represents different ways of assessing noise levels; in practice, they are combined and reported using nomenclature such as:

$45dBA_{DNL90}$
$85dBC_{N10}$
$34dBA_{N(10\text{-}min)}$

- **DN** (or **DNL**) Day-night level. This includes recordings taken through an entire 24-hour day and night. If no other time-related factors are included (such as "5-min" or L10), then a DNL of 43dB would mean that this is the average sound level over the entire day and night. As might be expected, daytime sound levels will be notably higher, and actual sound levels in the middle of the night much lower.
- **N** (or **NL**) Night level. This is a sound measurement taken only at night; while much more useful in setting noise limits, it typically includes early evening and pre-dawn, both of which often are louder than the middle of the night, thanks to frog and/or bird choruses and more human, so use of a night average should also be used advisedly if the goal is minimizing disruption in the middle of the night.

[11] Rogers, Anthony et al, Pg. 7
[12] Alberts, Daniel, Pg. 7
[13] Alberts, Daniel, Pg. 7

- **DEN (or Lden)** A 24-hour averaged (equivalent sound) "day evening night" sound level; used in European standards. Sounds recorded in evening are given a 5 dB extra weighting, and night sounds 10 dB extra, in determining compliance with these 24-hour standards.
- Shorter averaging times (5min, 10min, 30min, 60min etc.) These are sometimes used to better identify noise trends over the course of a night (or day). In some cases, regulations are based on the quietest of these periods, which is likely the most protective approach.

L_{10}, Leq, L_{90} When longer averaging times (e.g., all night) are used, some acousticians like to specify the following metrics, which can help in visualizing the variability of the noise levels during the period being considered, or provide a sense of the loudest and quietest parts of the period.

- **L90** or **L_{90}** This is the dB level that is exceeded 90% of the time; that is, it represents the quietest 10% of the time. It's sometimes used to establish the likely baseline of night time quiet.
- **L10** or **L_{10}** This is the dB level that is exceeded only 10% of the time; that is, it represents the loudest 10% of the time. L_{10} is sometimes used in lieu of tracking maximum sound levels, as it excludes anomalously loud sound events (e.g., the a plane or car passing a recorder measuring local noise levels, or an animal calling close to the recorder)
- **LEQ** or **Leq** Similar to an average, this value is calculated to be the "equivalent sound level" if all sound in the averaging period is combined, and then spread out through the period".[14] (This is the average that the Maine Site Location Law uses.)

Decibel Math

"The math in acoustics is not normal math based on logarithmic quantities. When you add a source of the same level to another source of the same level the increase is 3 dBA. For example, 60 dB plus 60 dB equals 63 dB as in the example below.

[14]Cummings, Jim, Acoustic Ecology Institute, "Wind Farm Noise, 2009 in Review", Pg. 8

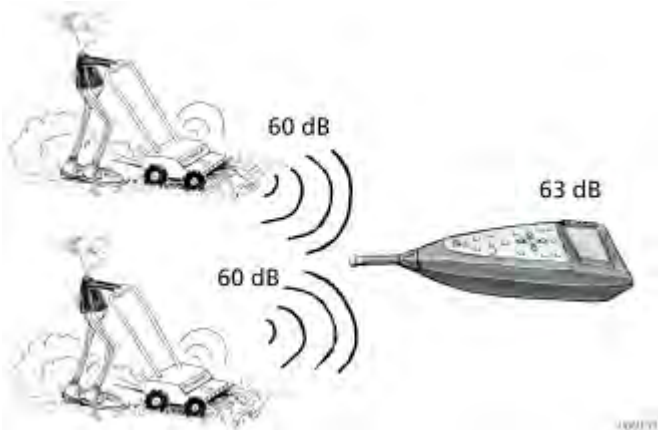


Figure 5: Decibel Math (Source: Bruel and Kjaer, Environmental Noise Booklet)

"This is generally considered the threshold of a perceivable difference when comparing similar sounds. When a source is 10 dB louder than another, there is no incremental change. Therefore, 50 plus 50 does not equal 100 when we are talking about sound levels in acoustics". [15]

Averaging

"Sound level meters give a numerical representation of the noise. However, this is obtained by averaging over a period of time that, for fluctuating noises, is generally longer than the period of the fluctuations, leading to a loss of information on the fluctuations. The widespread use of the equivalent level discards important information on the quality of the noise, its spectral properties and corresponding perceived sound character."[16]

International Electrotechnical Commission

"The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes international standards for all electric, electronic and related technologies. These serve as a basis for national standards."[17] The IEC is comprised of experts around the world that serve on various committees to develop such standards.

In the case of wind turbines, the IEC establishes standards for defining wind turbine sound power levels that allow manufacturers, developers and regulators to adhere to the same standards. Currently, sound standard 61411 Part 11, developed in 2002 is currently in use but the IEC has a technical committee working on an updated standard that is expected to be released in 2011.

[15]Bastasch, Mark, webinar
[16]Bellhouse, George, Pg. 9
[17]International Electrotechnical Commission, www.iec.ch

Wind turbine manufacturers should have sound data acquired using international standards, such as the IEC above or others, measuring sound from the wind turbines. Developers and regulators use this data in modeling expected sound levels at a site.[18]

Sounds from Wind Turbines

"Sound emissions from wind turbines have been one of the most studied environmental impact areas in wind energy engineering. The public's perception of the acoustic impacts of wind turbines, is, in part, a subjective determination." [19]

There are four types of sound that wind turbines generate:

1) "Tonal: sound at discrete frequencies that is caused by meshing gears, non-aerodynamic instabilities interacting with a rotor blade surface, or unstable flows over holes or slits or a blunt trailing edge.
2) Broadband: a continuous distribution of sound pressure with frequencies greater than 100 Hz. It is often caused by the interaction of wind turbine blades with atmospheric turbulence, and also described as a characteristic 'swooshing' or 'whooshing' sound.
3) Low Frequency: Sound with frequencies in the range of 10 to 100 Hz is mostly associated with downwind rotors. It is caused when the turbine blade encounters localized flow deficiencies due to the flow around a tower.
4) Impulsive: sound described by short acoustic impulses or thumping sounds that vary in amplitude with time. It is caused by the interaction of wind turbine blades with disturbed air flow around the tower of a downwind machine." [20]

Mechanical Noise

There are two categories of sounds caused from operating wind turbines. The first is *mechanical* and includes the parts of the turbine itself such as:

- Cooling fans
- Generator
- Power converter
- Hydraulic pumps
- Yaw motors
- Bearings
- Blades[21]

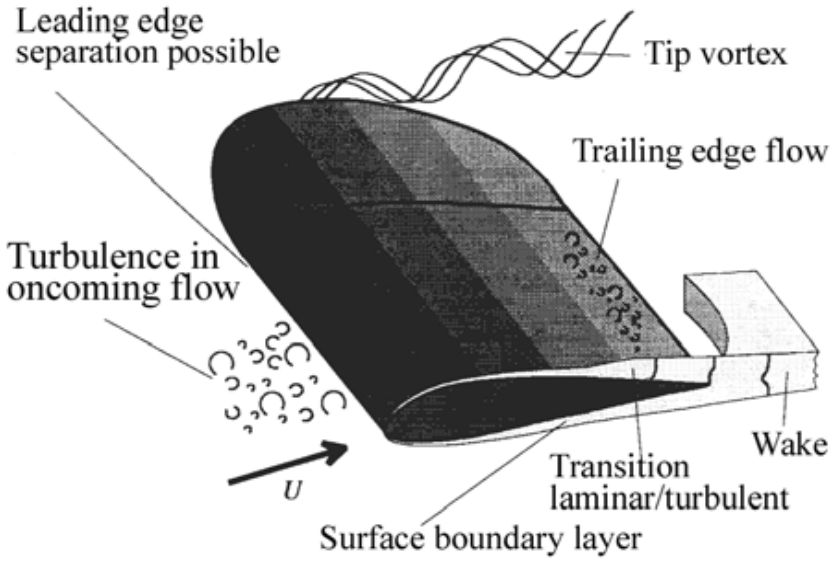
[18]Rogers, Anthony PhD., "Wind Turbine Noise, Infrasound and Noise Perception", Renewable Energy Research Laboratory, University of Massachusetts at Amherst, Powerpoint presentation, January 18, 2006
[19]Rogers, Anthony et al, Pg. 3
[20]Rogers, Anthony et al, Pg. 10
[21]Rogers, Anthony, Powerpoint presentation

Modern turbines are much quieter than previous models due to improvements in mechanical design. "Standard noise control measures are used to mitigate" mechanical sounds "and aerodynamic noise remains the likely dominant source." [22]

Aerodynamic Noise

The second category of sounds caused from operating wind turbines is *aerodynamic* and "is typically the largest component of wind turbines acoustic emissions. It originates from the flow of air around the blades as shown in Figure 6." [23]Aerodynamic noise includes low frequency, infrasound and airfoil noises.

Figure 6 : Schematic of flow around a Rotor Blade (Source: Wagner, 1996)



Low Frequency Sound and Infrasound

"Low frequency pressure vibrations are typically categorized as *low frequency sound* when they can be heard **near the bottom** of human perception (10-200 Hz) and *infrasound* when they **are below** the common limit of human perception. Sound below 20 Hz is generally considered infrasound, even though there may be some human perception in that range. There is a difference in the way sound attenuates in the atmosphere. Low frequency sounds are not attenuated as rapid of a rate as high frequency sounds". [24]

[22]Bastasch, Mark, webinar
[23]Rogers, Anthony et al, pg.11
[24]Bastasch, Mark, webinar

Infrasound is always present in the environment and stems from many sources including ambient air turbulence, ventilation units, waves on the seashore, distant explosions, traffic, aircraft, and other machinery.[25] "To place infrasound in perspective, when a child is swinging high on a swing, the pressure change on its ears, from top to bottom of the swing, is nearly 120 dB at a frequency of around 1 Hz.[26]

"There are a number of misconceptions about infrasound, such as that infrasound is not audible. Frequencies down to a few hertz are audible at high enough levels. Sometimes, although infrasound is audible, it is not recognized as a sound and there is uncertainty over the detection mechanism. Very low frequency infrasound, from one cycle in 1000 seconds (0.001Hz) to several cycles a second are produced by meteorological and similar effects and, having been present during all of our evolution, are not a hazard to us."[27]

According to Dr. Geoff Leventhall, this subject is very much misinterpreted and misused by certain activists and commentators. "It has been shown that there is insignificant infrasound from wind turbines and that there is normally little low frequency noise. Turbulent airflow conditions cause enhanced levels of low frequency noise, which may be disturbing, but the overriding noise from wind turbines is the fluctuating audible swish, mistakenly referred to as 'infrasound' or 'low frequency noise'. Objectors uninformed and mistaken use of these terms which have acquired a number of anxiety-producing connotations, has led to unnecessary fears and to unnecessary costs, such as for re-measuring what was already known, in order to assuage complaints.

Attention should be focused on the audio frequency fluctuating swish, which some people may well find to be very disturbing and stressful, depending on its level. The usual equivalent level measurements and analyses are incomplete, as these measurements are taken over a time period which is much longer than the fluctuation period and information on the fluctuations is lost. A time varying sound is more annoying than a steady sound of the same average level and this is accounted for be reducing the permitted level of wind turbine noise. However, more work is required to ensure that the optimum levels have been set."[28]
"Lower frequencies (of infrasound) must be of a higher magnitude dB to be perceived, for example, the threshold of hearing at 10 HZ is around 100 dB."[29] The human response to varying levels of infrasound can be described as the following:

[25]Bastasch, Mark, webinar
[26]Bastasch, Mark webinar
[27]Leventhall, Geoff, "A Review of Published Research on Low Frequency Noise and its Effects", A report for Defra, May 2003, Pg. 8
[28]Leventhall, Geoff, "Infrasound from Wind Turbines – Fact, Fiction or Deception", Vol. 34 no2. Canadian Acoustics, 2006, Pg. 34
[29]Rogers, Anthony, James Manwell and Sally Wright, "Wind Turbine Acoustic Noise", White paper for Renewable Energy Research Laboratory, University of Massachusetts, Amherst, June 2002, amended January, 2006 P. 9

- 90 dB and below: No evidence of adverse effects
- 115 dB: Fatigue, apathy, abdominal symptoms, hypertension in some humans
- 120 dB: Approximate threshold of pain at 10 Hz
- 120-130 dB and above: Exposure for 24 hours causes physiological damage[30]

A common assertion found in the acoustical literature suggests "there is no reliable evidence that infrasound below the perception threshold produces physiological or psychological effects". [31]

However, there is still a concern related to both infrasound and low frequency noise. Dr. Geoff Leventhall has written as recently as 2009 "although we know a great deal about low frequency noise, there are aspects which we cannot yet explain. We know about how people hear low frequency noise and that some have a low tolerance to it. We believe that low frequency noise may, in general, be more annoying than higher frequency noise, but do not know why this is so. We do not know why some people complain of a low frequency noise which cannot be measured separately from the background noise. It is also possible that there are subtle effects of low frequency noise on the body, which we do not yet understand".[32] Although these comments were made in relation to low frequency noise in general and not specifically related to wind turbines, there are still some unanswered questions.

More information on infrasound and low frequency noise will be discussed in a following section addressing wind turbines and potential health impacts.

Airfoil Sound
This type of noise includes "the sound generated by the air flow right along the surface of the airfoil. This type of sound is typical of a broadband sound but tonal components may occur due to blunt trailing edges, or flow over slits and holes."[33]

Amplitude Modulation (Tonal Sound)
The annoying "swish" mentioned earlier is commonly referred to as amplitude modulation. It is also described as having tonal components, a discrete whine or hum, is annoying and can result in increased sound levels over time. This is typical of most wind turbines and it is not low frequency sound, nor infrasound though it has often been confused as such.[34]

[30]Rogers, Anthony, et al, P. 9
[31]Rogers, Anthony, et al, P. 10
[32]Leventhall, Geoff "Low Frequency Noise. What we know, what we do not know and what we would like to know. Journal of Low Frequency Noise, Vibration and Active Control. Vo. 28, Number 2, 2009. Pg. 80
[33]Rogers, Anthony et al, Pgs. 11-12
[34]Bastasch, Mark, webinar

In the United Kingdom, complaints from several wind farms were received regarding low frequency noise and concerns (related to potential health impacts). Low frequency noise measurements were made inside the dwellings of three locations. The results of the Department of Trade and Industry's report found that "the common cause of complaint was not associated with low frequency noise, but the occasional audible modulation of aerodynamic noise (amplitude modulation) especially at night. Data collected showed that the internal noise levels were insufficient to wake up residents at these three sites. However, once awoken, this noise can result in difficulties in returning to sleep." [35]

The UK Department of Trade and Industry conducted a follow-up study investigating whether amplitude modulation has a "significant effect" by surveying local authorities, further investigating sites with amplitude modulation, conducting a worldwide literature search, and a survey of wind turbine manufacturers worldwide. The results of the study, which are applicable to wind turbine noise complaints in general and as they relate to amplitude modulation, include the following:

- 27 windfarms out of 122 received formal complaints about noise at some point in their history;
- Among the 27 windfarms, 231 complaints were received from 81 complainants;
- Just under half of the complaints were about mechanical noise and not related to amplitude modulation;
- The number of noise complaints related to the windfarms were compared to noise complaints generated from other sources and showed that general noise complaints exceed those of windfarms by between four and five orders of magnitude;
- 20% of windfarm installations were subject to complaints but no data is available on complaints from other types of noise to compare;
- Of the four sites that showed amplitude modulation it was found that these conditions might occur between 7-15% of the time;
- The literature search showed that the causes of windfarm noise has been researched extensively but "the complexity of turbulent flows means that prediction models are not yet completely reliable";
- "There is little published information on amplitude modulation. The causes of amplitude modulation are not fully understood and amplitude modulation cannot be fully predicted at current state of the art.";
- The survey of wind turbine manufacturers showed that they have little knowledge of amplitude modulation; and

[35] McKenzie, Hayes, "The Measurement of Low Frequency Noise at Three U.K. Windfarms", report for U.K. Department of Trade and Industry, 2006, pg. 1

- Few people are affected by amplitude modulation but because it "cannot be fully predicted at present, and its causes are not understood" it might be worth conducting further research.[36]

Wind Shear

"Wind shear is a measure of how wind speed increases with height and the ratio between the wind speed at ground level or between two elevations will vary based on a number of factors."[37] In other words, wind shear occurs when wind blowing at the top portion of a turbine is faster than the wind blowing at the base, or bottom portion of the turbine. This can be described as wind blowing in a "stable atmosphere" rather than a "neutral atmosphere" where wind blowing at the top of the turbine is more nearly the same as wind blowing at the bottom portion of the turbine.[38]

We understand that the current IEC standard does not take into account wind shear based on a stable atmosphere, but rather a neutral atmosphere, and it is unclear whether the new standard will take stable atmospheric conditions into account. This is important to note as it could potentially mean that the IEC standards could be currently underestimating noise levels from wind turbines. A draft has not yet been released.[39]

There is some disagreement in the literature as to the degree to which wind shear causes increased levels of amplitude modulation, but it has been found that "locations in flat landscapes do indicate an increase in the wind shear which is associated with stable atmospheric conditions."[40] However, it is clear that there are complaints associated with wind shear causing amplitude modulation and that it is not understood well enough to "provide design guidelines to minimize the potential for such a feature and is also still subject to debate."[41]

Warren Brown of EnRad, sound consultant to both DEP and LURC believes that wind shear does cause amplitude modulation in a stable atmosphere and that the IEC standards do not sufficiently take this into account. Consequently noise models require correction for wind shear effect uncertainty. The assumption of a neutral atmosphere used in modeling sound levels has led to expectations of substantial wind turbine masking during significant turbine operating conditions and does not account for the periodic nighttime occurrences of stable atmospheric conditions with subsequent increases in noise impact.[42]

[36]Moorehouse, Andy, Malcolm Hayes, Sabine von Hunerbein, Ben Piper and Mags Adams, U.K. University of Salford, "Research into Aerodynamic Modulation of Wind Turbine Noise: Final Report, prepared for defra, July, 2007, Pgs. 46-47
[37]Bastasch, Mark, webinar
[38]Brown, Warren, conversation, November 22, 2010
[39]Brown, Warren, conversation, November 22, 2010
[40]Moorehouse, Andy et al., P. 40
[41]Moorehouse, Andy et al., P. 40
[42]Brown, Warren, conversation, November 22, 2010

Sound Modeling for Wind Turbines

Data from wind turbine manufacturers is used in determining potential sound levels at a proposed wind energy development site. Computer models are used to predict noise levels near a wind turbine by taking into consideration the following: terrain effects, wind direction effects, atmospheric absorption, requirements of regulatory agencies and ambient background noise. Computer models also provide calculated noise pressure levels and maps of equal-noise-level contours. Noise assessments are performed by sound and acoustical engineers to determine the potential sound pressure levels at proposed wind developments taking into account noise produced from the turbine and comparing with ambient background noise.[43]

III. U.S. and International Noise Guidelines

Noise standards and regulations are generally set at the municipal and state level for wind energy development projects; however, there are several Federal government and World Health Organization noise guidelines worth mentioning for reason of comparison to Maine's noise standards for wind energy development projects.

U.S. Environmental Protection Agency's Noise Guidelines

Historically, the Environmental Protection Agency (EPA) "coordinated all federal noise control activities through its Office of Noise Abatement and Control". In 1981, that changed when the Administration moved responsibility of noise control activities to state and local governments. However, the *Noise Control Act of 1972* and the *Quiet Communities Act of 1978* are still in effect, although unfunded. A guidance document remains, entitled "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety". This guidance was meant as a resource to state and local governments in establishing noise standards and includes the following noise level recommendations:

- "24-hour exposure level of 70 dBAs as the level of environmental noise which will prevent any measurable hearing loss over a lifetime.

- Levels of 55 decibels outdoors and 45 decibels indoors are identified as preventing activity interference and annoyance. These levels of noise are considered those which will permit spoken conversation and other activities such as sleeping, working and recreation, which are part of the daily human condition.

- The levels are not single event, or "peak" levels. Instead, they represent averages of acoustic energy over periods of time such as 8 hours or 24 hours, and over long periods of time such as years. For example, occasional higher noise levels would

[43]Rogers, Anthony, "Wind Turbine Noise, Infrasound and Noise Perception", Renewable Energy Research Laboratory, University of Massachusetts, Amherst, Powerpoint presentation, January 18, 2006

be consistent with a 24-hour energy average of 70 decibels, so long as a sufficient amount of relative quiet is experienced for the remaining period of time.

- Levels of 45 decibels are associated with indoor residential areas, hospitals and schools, whereas 55 decibels is identified for certain outdoor areas where human activity takes place.

- The level of 70 decibels is identified for all areas in order to prevent hearing loss."[44]

According to the U.S. Environmental Protection Agency- the Day-Night Sound Levels - L_{dn} - and the Equivalent Sound Level - L_{eq} - should not exceed certain limits to protect public health and welfare.

Values that should not be exceeded are indicated in the table below:

Figure 7: Environmental Protection Agency's Values that Should Not be Exceeded (Source: www.epa.gov)

Effect	Level	Area
Hearing	$L_{eq}(24) < 70$ dBA	All areas
Outdoor activity interference and annoyance	$L_{dn} < 55$ dBA	Outdoors in residential areas and farms where people spend varying amounts of time in which quiet is a basis for use
Outdoor activity interference and annoyance	$L_{eq}(24) < 55$ dBA	Outdoor areas where people spend limited time such as school yards playgrounds, etc.
Indoor activity interference and annoyance	$L_{dn} < 45$ dBA	Indoor residential areas

[44]Environmental Protection Agency, http://www.epa.gov/history/topics/noise/01.htm

Indoor activity interference and annoyance	L_{eq} (24) < 45 dBA	Indoor areas with human activities such as schools, etc.

- Outdoor yearly L_{dn} levels protect public health and welfare if they do not exceed *55 dB* in sensitive areas as residences, schools, hospitals, etc.
- Inside buildings yearly L_{dn} levels protect public health and welfare if they do not exceed *45 dB*.

World Health Organization Community Noise Guidelines

Community noise is defined as all noises other than those emitted from the industrial workplace. The World Health Organization (WHO) has been addressing the issue of community noise since 1980. The intent of the WHO's Community Noise guidelines was to provide policy recommendations for European policy makers in order to address the problem of community noise in Europe through legislation and other means. "In the European Union about 40% of the population is exposed to road traffic noise with an equivalent sound pressure level exceeding 55 dBA daytime, and 20% are exposed to levels exceeding 65 dBA". [45]

The WHO Community Noise guidelines for dwellings and outside of dwellings (about 1 meter from living spaces) include the following recommendations:

- Indoors in bedrooms at night not to exceed 30 dB LAeq for continuous noise;
- Indoors in bedrooms at night not to exceed 45 dB LAeq for single sound events;
- Indoors during the day not to exceed 35 dB LAeq;
- Outdoor living areas during the day not to exceed 55 dB LAeq for continuous noise (to protect majority of people from being seriously annoyed);
- Outdoor living areas during the day not to exceed 50 dB LAeq (to protect majority of people from being moderately annoyed);[46]

We will discuss more from the WHO's Community Noise Guidelines in the section entitled "Potential Health Impacts". Although these guidelines do not directly address wind turbine noise they do provide current, peer-reviewed information on the impact of noise on the general population.

[45]World Health Organization, "Guidelines for Community Noise", 1999, Pg. 8
[46]World Health Organization, "Guidelines for Community Noise", 1999, Pg. 15

World Health Organization Nighttime Noise Guidelines for Europe

The intent of the WHO's Nighttime Noise Guidelines (NNG) was to provide scientific advice for the development of future legislation and policy action in the area of assessment and control of night noise exposure. The guidelines were developed by a working group of experts that considered the scientific evidence on the thresholds of night noise exposure. The working group concluded that using an Lnight, outside measurement that "40 dB should be the target of the NNG to protect the public, including the most vulnerable groups such as children, the chronically ill and the elderly. Lnight, outside value of 55 dB is recommended as an interim target for the countries where the NNG cannot be achieved in the short term for various reasons, and where policy-makers choose to adopt a stepwise approach".[47]

The following procedure was followed in order to derive an ordering of guideline values:

1. collection of relevant data
2. evaluation of data in terms of strength of evidence
3. evaluation of data in terms of biological effects, health and well-being
4. ranking of guideline values.[48]

It should be noted that the "Lnight standard" mentioned here is not the same as the Maine noise regulation which uses 10 minute or one hour average (Leq), measured at distances up to 500 feet from one's residence.

III. Setbacks for Wind Turbines

The literature shows a wide array of differing wind turbine setbacks. Typically, setbacks are established for safety reasons to avoid problems if turbines experience mechanical breakdowns such as falling blades, ice throw, etc. Safety setbacks are not meant to address noise concerns. There is not a specific wholly agreed upon setback standard that eliminates all noise complaints from nearby neighbors. Opponents of existing safety setback requirements argue that noise setbacks should be established between one-half mile and three miles in distance.

According to a comprehensive review undertaken by the State of Rhode Island, setbacks vary from state to state and sometimes differ even by county.[49] Numerous California counties have adopted setbacks primarily to address safety concerns, not to address noise. Regulations are typically based on overall turbine height from a property line. However, these setbacks are not based on a formal analysis of the rotor fragment hazard (when

[47] World Health Organization, "Nighttime Noise Guidelines, 2009, Pg. 8
[48] World Health Organization, "Nighttime Noise Guidelines, 2009, Pg. 26
[49] Rhode Island. Terrestrial Wind Turbine Siting Report, January 13, 2009

rotor blades disengage from the turbine tower). The authors of this study suggest that such a study should be undertaken.[50]

Maine's statutory safety standard is 1.5 times the height of the turbine and is based on the manufacturer's or an engineer's recommendations.

To illustrate the point of varying setbacks, the following chart highlights the minimum

Table 2
Summary of US Siting Criteria of Wind Turbines

Criteria	Minimum Distance or Noise Std. / (Jurisdiction)	Maximum Distance or Noise Std. / (Jurisdiction)
Distance from Property Line	50 feet / (NYS Energy R&D Authority)	810 ft / (Calumet County). WI) 1260 ft / (MN Wind Farm Setback)
Distance from Nearest Structure	1.1 times height of the tip of the turbine blade (~ 450 feet) / (PA Municipality Planning code Model Ordinance)	1500 feet / (Geary County KS and NYS Energy R&D Authority)
Distance from Roads	250 feet / (MN PUC)	Door County. WI 1000 ft or 3 X Wind turbine height* (1215 ft)
Icing		250 M ~ 820 feet
Public Safety		1 ½ times the total height of a turbine. (607.5 ft.)
Noise Standard Based Distance from Property Line	50 DBA / 45 DBA Pure Tone (Wisconsin Model Ordinance)	65 DB / (Riley KS)
Noise Standard Based Distance from Nearest Structure	50 DB / (NYS Energy R&D Authority, MN PUC) 10 DB above ambient / Door County WI)	55 DB/ (PA Municipality Planning code Model Ordinance)
Distance from shoreline (RI recommendation for avian concerns.)	300 feet	600 feet

Figure 8: Summary of U.S. Siting Criteria of Wind Turbines (Source: Rhode Island's Terrestrial Wind Turbine Siting Report)

IV. Maine's Noise Regulations

An Act to Implement Recommendations of the Governor's Task Force on Wind Power Development

LD 2283 "An Act to Implement Recommendations of the Governor's Task Force on Wind Power Development", Public Law 2008, Chapter 661 (*Wind Power Development Act*) established findings as to the importance of wind power development in Maine, streamlined the permitting process and established expedited permitting areas and wind power development goals, added a new statutory requirement that regulated shadow

[50] Larwood, Scott and van Dam, C.P. (California Wind Energy Collaborative) 2006 Permitting Setback Requirements for Wind Turbines in California, California Energy Commission, PIER Renewable Energy Technologies, CEC-500-2005-184.

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flicker from turbines, required tangible benefits and removed the requirement that wind power projects must visually fit harmoniously into the existing natural environment. The law did NOT modify or require changes in the state's existing noise regulations. Instead, the law stated that projects must comply with the DEP's existing Site Location Law, Chapter 375.

The law did specifically include requirements for public safety setbacks of wind turbines based on a recommendation from a licensed civil engineer as well as any recommended setbacks made by the turbine manufacturer. Most grid-scale turbines in Maine are General Electric (GE) 1.5 MW turbines and Vestas 3 MW turbines are in use at TransCanada's Kibby project. GE's recommended turbine safety setbacks are 1.5 times the maximum height of the turbine from a property line or building which is approximately 582 feet. Vestas' recommended setbacks for their 3 MW turbines are also 1.5 times the height of the turbine which is approximately 615 feet. The height depends on the overall height of the unit as constructed. Setbacks and shadow flicker were not identified by the Utilities and Energy Committee to be addressed in this study; however, we do address the issue of setbacks briefly.

Maine Department of Environmental Protection's Site Location Law

The regulation that applies limits to noise levels for all development projects over 3 acres is DEP's Chapter 375, which embodies the "No Adverse Environmental Effect" Standard of the Site Location Law, including proposed wind energy development projects in DEP's expedited permitting areas, and projects less than 100 kW in size. The same standards apply in the LURC's jurisdiction in expedited permitting areas but not in areas that the legislature did not designate as expedited or for wind turbines that don't meet the statutory definition of "wind energy development". The LURC's jurisdiction comprises about half the state, and roughly a third of that jurisdiction has been designated as expedited. LURC has similar noise standards for projects in the unexpedited areas and for projects that don't meet the "wind energy development" definition, including projects less than 100 kW discussed below.

Municipalities that are not in LURC jurisdiction and have adopted noise standards adhere to their own noise standards when permitting wind energy development projects in their jurisdictions as long as their noise standards contain limits no more than 5 dBA higher than the Site Location Law and limits or addresses the types of noises contained in the law.

The Site Location Law was originally adopted in 1979 with amendments to Section 10: Noise Control, adopted in 1989 and other sections amended in 1991, 2001 and 2006. DEP has considered amendments to regulations implementing the Site Location Law with the exception of Section 10: Noise Control in anticipation of this examination and report to the Legislature related to noise and wind energy development.

Application Requirements

The Site Location Law requires all proposed developments that will potentially produce a major noise impact to undertake a full noise study prepared by a professional as part of the site development application. All proposed wind energy developments in Maine are assumed to produce a major noise impact and thus require a full noise study. The following information must be provided:

(1) Baseline

(a) Uses, zoning and plans. Maps and descriptions of the land uses, local zoning and comprehensive plans for the area potentially affected by sounds from the development.

(b) Protected locations. Descriptions of the protected locations near the development.

(c) Quiet area. Evidence concerning whether or not the area surrounding the development is a quiet area.

(2) Noise generated by the development

(a) Type, source and location of noise. A description of all types of noise to be generated, sources of noise and locations of noise sources.

(b) Sound levels. A description of the daytime and nighttime sound levels expected at property lines and protected locations for all types of sound generated.

(c) Control measures. A description of proposed sound control measures, locations and expected performance.

(d) Comparison with regulatory limits. A comparison of expected sound levels with sound level limits in regulations.

(e) Comparison with local limits. A comparison of expected sound levels with any quantifiable noise standards of any affected municipality.

Sound Level Limits

Sound level limits vary according to zoning (commercial, transportation, industrial, residential), use (routine operations, construction, maintenance activities and blasting) as well as the time of day and night. There are also numerous exemptions such as aircraft and railroad equipment sound levels which are subject to federal rules.

Sound level limits apply only to property lines of the proposed development or contiguous property owned by the developer and "protected locations", whichever are farther from the proposed development's regulated sound sources. "Protected locations" are defined generally as a residence, school, library, State Park, or wildlife refuge (and others).

Property lines of the proposed development serve as "compliance points" in which sound is measured. A 500-foot circle, measured from outside and around the building or site, of a "protected location", also serves as a compliance point.

The standard in which "a proposed development is to be located in an area where the daytime pre-development ambient hourly sound level at a 'protected location' is equal to or less than 45 dBA and/or the nighttime pre-development ambient hourly sound level at a protected location is equal to or less than 35 dBA, the hourly sound levels resulting from the routine operation of the development and measured in accordance with the measurement procedures as described in subsection H is not to exceed the following limits at that 'protected location.' "[51]

55 dBA between 7:00 a.m. and 7:00 p.m.
(Daytime hourly limit) and
45 dBA between 7:00 p.m. and 7:00 a.m.
(Nighttime hourly limit)

In determining pre-development ambient hourly sound levels the developer may make sound level measurements in accordance with section H of the Site Location Law or may estimate the sound-level based upon the population density and proximity to local highways or demonstrate that the hourly sound levels resulting from routine operation of the development will not exceed 50 dBA in the daytime or 40 dBA at night. It is important to note that in determining pre-development ambient levels the sound of turbine noise is excluded.

With the exception of the Mars Hill wind project (which was granted a variance from the "quiet area" standard) and the Kibby and Stetson I projects which were permitted by LURC prior to the *Wind Energy Act*, ALL of the permitted wind energy development projects in Maine have fallen under the Site Location Law's or Small Scale Certification's routine operation of development's "quiet area" standard as described above.

Sound Modeling & Measurement

Acoustic engineers construct predictive models to estimate the sound output that will be produced from a wind energy development. The sound models take into account the specific equipment producing the sound as well as the physical characteristics and weather patterns of the landscape surrounding the development. The DEP does not have acoustic engineers or experts on staff, nor is there any funding available for hiring such staff at this time. However, DEP and LURC have hired a consultant, Warren Brown of EnRad of Maine to review sound models to ensure that the models are constructed in a manner that is technically accurate. The DEP requires that approved wind energy developments that will produce sound conduct periodic compliance measurements in order to ensure that the actual sound produced by a development is consistent with the predictive model and in compliance with the State's noise regulations.

[51]Maine. Department of Environmental Protection Site Location Law, Chapter 375, Pg. 3

The DEP noise standards require among other things that all compliance measurements be calculated by recording all sounds produced within a continuous 1 hour period and calculating the average (1 hr L_{eq}) sound level for the period, be supervised by qualified personnel and that measurement periods should be avoided when the local wind speed exceeds 12 mph. Compliance monitoring of wind power facilities is therefore very difficult given the fact that measurements must be taken when the wind is blowing and the facility is in operation and this almost invariably involves wind speeds that exceed 12 mph.

Analysis of existing wind projects both in Maine and in other jurisdictions has led the DEP's and LURC's sound consultant to conclude that the best time to measure predominantly wind turbine sound is during nighttime periods of inversion and increased wind shear. These conditions result in increased wind speeds at the turbine hub level with calm to light surface level winds. The inversion/wind shear conditions occur regularly at most locations but may be challenging to predict making physically supervised measurement of sound from the development by a trained sound technician difficult and expensive. Additionally, proper conditions may occur intermittently or be interrupted by other noises during an overnight making impractical a continuous 1 hour period as required in the State's noise regulations.

In order to overcome these compliance measurement obstacles the DEP, on the advice of their sound consultant, requires that wind energy developers collect compliance data in continuous 10 minute (10 min L_{eq}) blocks of time instead of the existing standard's 1 hr L_{eq} and on a singular occasion has allowed a specific wind energy project to set up automated sound measurement stations at protected locations in lieu of having a sound technician physically on the site during the testing period. The automated equipment measures sound, wind speed and direction and produces an audio recording of the actual conditions on the site during the measurement period. From this information acoustic engineers and the DEP can select periods of data from within the sample in which the required measurement conditions have been met.

There are 5 dBA penalties for tonal and short duration repetitive sounds in Maine's noise regulations. Projects must meet a 45 dBA *average* level of sound over an hour time period. Sound spikes that go over 45 dBA are not counted per se as triggering a project out of compliance unless the average is over 45 dBA.

Variances

The BEP, DEP Commissioner or LURC may grant a variance from any of the sound level limits included in the rule based on a number of factors as part of a completed Site Location Law application, or LURC Development Permit application, and may impose certain terms and conditions. The only variance that has been issued to date was for the Mars Hill project.

Appeal Process
For DEP projects, once an application has been completed, submitted and reviewed, a final decision is made by the DEP Commissioner. A draft copy of the Findings of Fact and Order is made available upon request for review by all interested parties at least 5 working days prior to final action by the commissioner, or 15 working days prior to final action by the BEP. An appeal of the decision can be filed within 30 days following final action.

Currently, there are four wind energy development applications that have been approved by the DEP Commissioner and have been appealed. The four that have been appealed include the Rollins Mountain, Record Hill/Roxbury, Oakfield and Spruce Mountain projects. The Rollins Mountain, Record Hill/Roxbury and Oakfield projects were appealed to the Maine Law Court based on whether the DEP's noise standard is adequate. The Spruce Mountain appeal is currently pending before BEP. The Law Court ruled that the noise standard is adequate. The Rollins and Record Hill projects are now under construction, although construction on Record Hill has been suspended pending the resolution of the appeal.

Small Scale Certification
For wind energy development proposals that do not trigger the Site Location Law, applicants apply to DEP for a small scale certification for their project. The certification requires the same noise standards as included in the Site Location Law as well as shadow flicker and safety setbacks included in the Maine Wind Power Development Act. Noise compliance for a small scale certification is the same as for the Site Location Law.

Land Use Regulation Commission's Chapter 10 Noise Standards
The LURC's Chapter 10 noise standards are applicable to projects NOT located in the expedited permitting areas, and to projects that do not meet the definition of "wind energy development", including projects smaller than 100 kW. LURC's jurisdiction consists of the unorganized and deorganized areas of the state and some towns and plantations which choose not to do their own planning and zoning. LURC is responsible to review all types of development in its jurisdiction, including wind energy development projects. Approximately one-third of LURC's jurisdiction has been designated as expedited permitting areas for wind energy development.

The LURC noise standards include the following: "the maximum permissible sound pressure level of any continuous, regular or frequent source of sound produced by any commercial, industrial and other non-residential development shall be as established by the time period and type of land use sub-district listed below. Sound pressure levels shall be measured at all property boundary lines, at a height of at least 4 feet above the ground

surface. The levels specified below may be exceeded by 10 dBA for a single period, no longer than 15 minutes per day".[52]

Figure 9: LURC Zoning Sub-districts	7:00 AM to 7:00 PM	7:00 PM to 7:00 AM
D-CI, D-MT, and D-ES	70 dB(A)	65 dB(A)
D-GN, and D-GN2	65 dB(A)	55 dB(A)
D-PD	As determined by the Commission.	
All Other Sub-districts	55 dB(A)	45 dB(A)

Figure 9: LURC Zoning Sub-districts (Source: LURC Chapter 10 rule)

Certain activities are exempt from the Chapter 10 noise standards, including: construction-related activities, sounds from safety and warning devices, and sounds from traffic on roadways or other transportation facilities.
Control of noise for a wind energy development in the expedited permitting area under LURC's jurisdiction with a generating capacity greater than 100 kW is not governed by this section and instead is governed solely by DEP's Site Location Law which was discussed above.

V. Other Jurisdictions' Noise Regulations

Following are a few examples of sound standards in other U.S. states and Europe worth noting. Particularly, Oregon and Wisconsin who are undergoing, or have just undergone, a public process for assistance in determining noise regulations and impacts from wind energy developments.

Oregon
Oregon has more than 1,200 wind turbines in operation, produces 2,095 MW of wind capacity and ranks fourth behind Texas, Iowa and California in wind energy development, according to the American Wind Energy Association.

In 1975, Oregon established an Energy Facility Siting Council (Council) comprised of volunteer public members nominated by the Governor and confirmed by the Oregon Senate. The Council has regulatory and siting responsibility for the development of large electric generating facilities over 105 MW (including wind energy developments), and transmission projects, among others. Municipalities may adopt their own standards and the state has established a model ordinance.

[52]Maine. Maine Land Use Regulation, Chapter 10: Noise Standards

Separate wind power development noise standards are governed by The Environmental Quality Commission's (EQC) OAR Chapter 340, Division 35. There is no noise permit, but the EQC noise standards apply to all industrial facilities, including wind energy facilities.

In general, Oregon's noise standards are compared to an increase in noise levels based on an assumed background L_{50} ambient noise level of 26 dBA or the actual ambient background level, which may be measured to determine the actual ambient background levels. One can exceed the ambient noise levels by more than 10 dBA (but not above the limits below in Table 8 of the regulations), IF the developer secures an easement that benefits the property where the wind development is located.

Table 8
New Industrial and Commercial Noise Source Standards
Allowable Statistical Noise Levels in Any One Hour

7 am – 10 pm	10 pm – 7am
L_{50} – 55 dBA	L_{50} 50 dBA
L_{10} – 60 dBA	L_{10} 55 dBA
L_1 - 75 dBA	L_1 60 dBA[53]

For proposed wind energy developments where a landowner has not waived the standard, noise levels are predicted corresponding to the maximum sound power level as established by IEC 61400-11C (version 2002-12) compared with the highest of either the assumed ambient noise level of 26 dBA or the actual ambient background level, if measured. Compliance is established if it is shown that the increase in noise is no more than 10 dBA over the entire range of wind speeds.[54]

Oregon is currently undertaking a health assessment on wind energy development and held three listening sessions across the state in November, 2010. "The Oregon Public Health Division is working with a broad range of stakeholders to:

- identify and document the major health concerns related to wind energy facilities
- use the best available science to evaluate potential health risks
- work with partners and decision-makers to ensure health is considered during the siting process
- provide community members with timely and useful information, and opportunities to be involved in our work

[53]Oregon. Department of Environmental Quality, Administrative Rules Chapter 340, Division 35
[54]Oregon. Department of Environmental Quality, Administrative Rules Chapter 340, Division 35

A steering committee is being formed to oversee their work in this area. This committee will include representatives from communities near wind energy facilities, local and state government agencies and decision-makers, and renewable energy developers".[55]

Massachusetts

In Massachusetts, regulations for siting and placement of wind turbines are determined by each municipality, however, the state has developed a model bylaw that many communities have adopted as standards for wind energy developments. Specific noise standards fall under Massachusetts' Department of Environmental Protection's (Mass DEP) Noise Control Regulation 310 CMR 7.10 as a form of regulated air pollution. These regulations apply to all industrial developments, not only wind energy developments.

Noise evaluations are performed when the agency receives complaints from the public. Enforcement focuses on "protecting affected people at their residences and in other buildings that are occupied by sensitive receptors from nuisances and public health effects of noise".[56]

"The policy specifies that the ambient sound level, measured at the property line of the facility or at the nearest inhabited buildings, shall not be increased by more than 10 decibels weighted for the "A" scale [dB(A)] due to the sound from the facility during its operating hours.

The guideline further states that the facility shall not produce a pure-tone condition at the property line (or at the nearest inhabited buildings). A pure-tone exists if the sound pressure level, at any given octave band center frequency, exceeds the levels of the two adjacent octave bands by three (3) or more decibels."[57]

A new noise source that is proposed to be in an area in a commercial or industrial area with no sensitive receptors (or likely to become a residential area) may not be required to mitigate its noise impacts even though predicted sound levels are expected to be more than 10 dBA. However, if noise levels are found to be over 10 dBA over L_{90} levels at the property line at other sites, mitigation is required.[58]

For noise compliance monitoring, the Mass DEP has no specific standard. The noise policy was developed prior to wind energy development in the state and they are currently "playing catch up" as their noise policies were not designed for wind turbine sound sources. With the advent of several wind power proposals in Western

[55]Oregon Health Impact Assessment, www.oregon.gov/DHS/ph/hia/windenergy.shtml
[56]Massachusetts. http://www.mass.gov/dep/air/laws/noisepol.htm
[57] Massachusetts. http://www.mass.gov/dep/air/laws/noisepol.htm
[58] Massachusetts. http://www.mass.gov/dep/air/laws/noisepol.htm

Massachusetts, and complaints at one existing site in Falmouth, Massachusetts, the Mass DEP plans to initiate an informal stakeholder process to evaluate the pitfalls of their existing policy as they have received complaints from projects in which the measured sound levels are 10 dBA L_{90} *below* the standard.[59]

Wisconsin

The Wisconsin Public Service Commission (PSC) recently finalized wind energy development siting rules, resulting in six months of work by the PSC's Wind Siting Council (Council). The Council, a 15-member advisory board to the PSC was created by statute in 2009 to develop administrative rules for siting wind energy developments, to advise the PSC on new standards, and to specify restrictions that local municipalities can impose on wind energy developments under 100 MW. The legislation was the result of a patchwork of local regulations some of which were very restrictive making it difficult for wind energy projects to move forward. The PSC held numerous public hearings and accepted over 1,800 public comments. The final draft rules were sent to the Legislature's Senate Energy Committee, where public comments were taken and the rules discussed, only to be sent back to the PSC for modification. The PSC adopted the final rules with modifications on December 27, 2010. The final rule includes the following

- A municipality can require wind energy development projects not to exceed 45 dBA during nighttime hours and 50 dBA during daytime hours. Noise limits are measured from the outside wall of non-participating residences and occupied community buildings.

- Wind energy development owners are required to provide "good neighbor payments" to non-participating landowners located within one-half mile of a wind turbine site not exceed $800. For 3 or more turbines, payments are not to exceed $1,000. A mechanism is included to automatically adjust the amount each year.

- A municipality can impose minimum safety setbacks of 1.1 times the maximum blade tip height of a wind turbine for participating residences, setbacks the lesser of 1,250 feet or 3.1 times the maximum blade tip height of a wind turbine for non-participating residences and occupied community buildings.[60]

New Hampshire

The New Hampshire Energy Facility Evaluation, Siting, Construction and Operation Act sets forth the following criteria for the permitting of renewable energy facilities (and bulk power projects) over 30 MW under the jurisdiction of the state's Site Evaluation Committee (SEC):

[59]Wallman, Mark, Conversation, Massachusetts Department of Environmental Protection, December 1, 2010

[60]Wisconsin Public Service Commission. November 13, 2010

The Committee must find that the proposed site and facility:

a) The applicant has the adequate financial, technical, and managerial capability to assure construction and operation of the facility in continuing compliance with the terms and conditions of the certificate.
b) Will not interfere with the orderly development of the region with due consideration given to the views of municipal and regional planning commissions and municipal governing bodies.[61]

Regulation of noise levels in New Hampshire falls within the jurisdiction of individual municipalities. However, NH RSA 162-H requires the SEC to find that the project "will not have an unreasonable adverse effect on aesthetics, historic sites, air and water quality, the natural environment, and public health and safety."[62] In addition, the SEC's draft rules specifically require that applications address the issue of noise.

In June, 2006 the New Hampshire Legislature established the Energy Policy Study Commission report. One of the topics for study included "the regulatory process for siting commercial wind energy facilities in the state and the economic, environmental, visual and ratepayer effects associated with such facilities." An ad-hoc wind power siting guidelines working group was formed to study the issue. A final report was issued in May, 2007 in which a number of recommendations were made. However, in regard to noise the group did not reach consensus as to "whether noise levels or distance from source should be the basis for developing assessment guidelines or evaluating the relative level of concern". The group concluded that they did not have sufficient expertise to come to a conclusion on the issue of noise. [63]

International Noise Standards

For a thorough review and comparison of noise standards from the U.S., Canada and Europe see Ontario's Ministry of the Environment's Wind Turbine Facilities Noise Issues.[64] (Go to: www.maine.gov/oeis pages 26-29)

Below is a table that compares the U.S., Japan and several European countries' noise standards and setback distances.

[61] New Hampshire. Wind Energy Facility Siting Guidelines Working Group, "Proposed Windpower Siting Guidelines", May 29, 2007, Pg. 1
[62] New Hampshire. "Proposed Windpower Siting Guidelines", Pg. 2
[63] New Hampshire, "Guidance for Evaluation of Individual Issues; Noise, Wind Energy Facility Siting Guidelines Working Group, Proposed Windpower Siting Guidelines, Appendix A.11 Noise, May 29, 2007
[64] Ontario. Ministry of the Environment's "Wind Turbine Facilities Noise Issues", December, 2007 Pgs. 26-29

Figure 10	Day	Night	LDN	LDFN	Setback Distance
US			55 dB(A) (EPA Guidelines)		200m -500m
Germany	<45 dB				
Ireland	45 dB(A)	43 dB(A)			500 m
Japan	50 dBA	40 dBA			200m -500m
Ontario	40 dBA - 51 dBA				>550m
Netherlands	41 dBA			47 dBA	
Denmark	44 dB(A) (39 dB(A)				
Switzerland	50 dBA	40dBA			

Figure 10: U.S., Japan and European countries' noise standards and setbacks. (Source: National Renewable Energy Lab's Power point presentation, Oct. 13, 2010)

VI. Maine Wind Energy Development Projects

As previously discussed, a complete list of wind energy projects in varying stages of development i.e. operational, under construction, permitted, and under development is included in Part A of this report. The following projects are noted here in order to provide a chronological listing of wind energy development projects that have experienced problems or have developed successful best practices that we can learn from for future projects.

Wind Energy Development Projects Located in DEP's Jurisdiction
DEP's jurisdiction includes all of the expedited permitting areas which include all organized areas of the state. The DEP's Chapter 375 Site Location Law's noise regulations apply to all projects located in the expedited permitting areas and projects proposed for a Small Scale Certification (under 3-acres in size).

Beaver Ridge/Freedom
The 4.5 MW, 3-turbine Beaver Ridge wind energy project located in Freedom, built by Competitive Energy Services (now owned by Patriot Renewables) was approved by the Freedom Planning Board in 2006. The town voted down a moratorium on the project in 2008, before the Wind Power Development Act was signed into law. Therefore, the current noise, safety setback and shadow flicker requirements were not applied to this project. In addition, the project did not trigger DEP's Site Location Law because the site was less than three acres in size so DEP has no authority to monitor this project for noise compliance. The noise, setback and shadow flicker regulations were decided by the town's local Planning Board, not the State.

Mars Hill

The 42 MW, 28-turbine project located in Mars Hill was built by First Wind and was subject to DEP's Site Location Law and noise regulations. However, First Wind applied to the DEP Commissioner and was granted a variance, increasing the sound dBA level from 45 dBA to 50 dBA.

Pre-commissioning tests of turbines at Mars Hill in 2006 swiftly brought complaints of noise from nearby property owners. Shortly after commercial operations began in March 2007, First Wind voluntarily initiated a compliance monitoring program that included a quarterly operations sound testing regime in consultation with DEP and a local landowner's association. At this time, there was no formal sound measurement compliance protocol in place.

DEP hired Warren Brown of EnRad Consulting to perform a peer-review and determine 1) whether the post-development report and its assumptions were correct and 2) whether the testing reports provided a reasonable basis to determine compliance sound levels from other sources.
A sound level monitoring protocol (Protocol) was submitted to the DEP and approved prior to initiating the first quarterly operations sound level test in May 2007. The Protocol was reviewed and refined, with input from the peer reviewer, on the last three sound level tests.

In response to the first two quarter sound level tests, Warren Brown in his peer review report entitled "Mars Hill Wind Farm Post-Development Sound Level Study" in November, 2007 analyzed quarterly testing data from December 2006, and May 2007. He found that "the ambient and operating level sound study was compromised by the use of inadequate microphone wind protection and/or site specific wind condition information". His review showed "substantial compliance but required further measurement technique refinement with additional measurements."

His recommendations included the following:

1) Use ground level anemometers at monitoring locations
2) Complete future sound level measurements during other seasons of the year, including winter, including with snow cover and turbine blade icing.
3) Sound measurements required and wind speeds more than 12 mph should be done consistent with manufacturer microphone/windscreens and/or appropriate specified secondary windscreens.[65]

[65]Brown, Warren, Mars Hill Windfarm post Development of Sound Level Study Peer Review, November 21, 2007

A total of four quarterly testing regimes were performed, along with ambient-noise level testing, from 2007-2008 by First Wind's sound consultant Resource Systems Engineering (RES). A post-development sound level report was issued by RES in October, 2008 entitled "Sound Level Study: Compilation Of Ambient & Quarterly Operations Sound Testing".

RES' conclusions included the following:

- "Results from all four quarterly tests showed reliable and consistent measurements of community sound levels attributable to operation of the Wind Farm. The overall range of measured hourly sound levels from wind turbines at or above 60% power generation (900 kW) was 5 dBA below to 6 dBA above the 2003 model estimates. The bulk of these measurements were within 1 to 4 dBA above the model estimates. These differences might be accounted for by manufacturer's uncertainty factor (+2 dB) in sound power determination and differences between measurement of sound power when using IEC Standard 61400-11 versus recognized acoustical engineering field methods such as set forth by ANSI standards.

- Wind turbine sound levels were compared with non-wind farm ambient sound levels. Similar to wind farm sound levels, ambient sound levels vary with wind speed. At each of the monitoring positions, sound levels from wind farm operations were within the range of ambient sound levels. Due to their lower elevations, wind speeds at the monitoring positions are typically five to ten miles per hour less than at the turbine hubs. As shown by quarterly test results, this difference can increase depending upon the general wind direction, wind gradients, and amount of shielding from the terrain and vegetation. When wind turbine sound was more prominent, the winds were generally light compared to wind incident at the turbine hubs. In these instances, measured sound levels from the Wind Farm were above sound levels from other sources. Even with periodic turbine shutdowns, a direct comparison of operating and ambient (non-turbine) sound levels is complicated by the wide range of ambient sound levels that can occur during wind conditions that support moderate to full Wind Farm operations."[66]

In December 2008, Warren Brown of EnRad issued its final report entitled "Mars Hill Windfarm Post-Development Quarterly Sound Level Assessment Compilation -- Peer Review". The report concluded that "compliance had been reached at all bordering protected locations with only substantial compliance at one protected location and that the developer's study was reasonable, and technically correct according to standard

[66]Resource Systems Engineering, "Mars Hill Sound Level Study: Compilation Of Ambient & Quarterly Operations Sound Testing", October 15, 2008, Pgs. 39-40

engineering practices and the Department Regulations on Control of Noise (06-096 CMR 375.10)"[67].

The report did include specific recommendations that should be considered in the future. These recommendations included:

- "Future, windfarm sound level predictions employing the same methodology as those performed at Mars Hill by RSE (First Wind's sound consultant) should be evaluated with a possible ± 5 dBA range of variability.

- Future compliance testing performed at protected locations likely to receive operation sound levels equaling or exceeding regulatory limits should be evaluated over a period sufficient to accumulate a total of 36 hours each of ambient and routine operation sound level data during conditions when surface wind speeds are 12 mph and nearby turbine hub level winds are sufficient to produce at a minimum, near-full sound power predictions as per manufacturer specification.

- Sound monitoring devices should be positioned to most closely reflect each protected location (especially the residences), avoiding non-representative, localized, potential noise sources. Meteorological measurements should be generally position specific (but not necessarily in immediate proximity to sound monitoring instruments), unobstructed (where possible) and most importantly reporting average/maximum speed per unit time, representative of all wind directions.

- Prominent, routine operation sound monitoring results should be reported for periods where maximum surface wind speeds are 12 mph and displayed together with maximum and actual hourly predictive sound levels based on hub level wind speeds and manufacturer's specification, less attenuating factors (as employed in the original predictive model).

- Parameters to be reported: ambient sound levels should include a 1 hr $L_{eq,}$ average hourly unobstructed wind speed/maximum in mph at hub and surface (8' – 10') levels, and routine operations should include, by site; specific acoustic factors—maximum/actual hourly predictive levels, hourly L_{eq} etc. and average hourly unobstructed wind speed/maximum in mph. Representative area NOAA meteorological wind data inclusion is strongly suggested.

[67]Brown, Warren "Mars Hill Windfarm Post-Development Quarterly Sound Level Assessment Compilation -- Peer Review", December 8, 2008, Pgs. 4-5

- Future wind turbine reporting should use a standard mph metric for wind speed; report average hourly wind turbine sound power level (respective nearby wind turbines), as per manufacturer specification (less attenuating factors) and hourly average sound levels L_{eq}."[68]

At this time, First Wind's Mars Hill project is substantially in compliance with the permit that it was issued.

Vinalhaven

The 4.5 MW 3-turbine project was built by Fox Island, LLC and was subject to DEP's small scale certification because the project site was less than 3-acres in size. The project is located on Vinalhaven Island in the Penobscot Bay.

DEP issued a small scale wind certification for the project. The project was designed to meet a 50 dBA threshold based on calculations made by the developer that they felt indicated that the area surrounding the development was not a quiet area and therefore should not be subject to the quiet area standard of 45 dBA. In reviewing the project the DEP disagreed with the ambient measurement procedures undertaken by the applicant and did not accept the assertion that the affected area of Vinalhaven was not a quiet area and held the developer to the 45 dBA quiet area standard.

In order to meet the standard, the developer agreed to operate the facility in noise reduction operation (NRO). NRO is a manufacturer setting that effectively slows down the maximum rotation of the turbine resulting in reduced sound output. By agreeing to operate with an NRO setting the developer was able to demonstrate that the project could meet the 45 dBA noise standard. The DEP noted in the certification for the project that there was a likelihood that the facility could operate out of compliance with the noise standards under conditions that included vertical and directional wind shear. The DEP required that the developer follow a prescribed operational sound measurement protocol that was designed to measure compliance under the conditions that were most optimal for determining wind turbine sound.

On July 23, 2010 the DEP received a complaint alleging that the development had exceeded the 45 dBA noise limit on July 17, 2010 and July 18, 2010. An investigation of the complaint by the DEP determined that there was a period of non compliance with the State's noise standards during a portion of the complaint period and the DEP notified the licensee of the determination on November 23, 2010. The licensee is required by DEP to submit a revised operational protocol to the DEP for review and approval by no later than January 23, 2011. The revised operational protocol must outline the measures that will

[68]Brown, Warren "Mars Hill Windfarm Post-Development Quarterly Sound Level Assessment Compilation -- Peer Review", Pg. 5

be taken by the licensee to ensure that the development remains in compliance at all times.

The Vinalhaven developers are currently working on a number of mitigation strategies in order to reduce the noise impacts from their project. Fox Island, LLC is working with the U.S. Department of Energy, the National Renewable Energy Lab (NREL), General Electric and Lawrence Berkeley National Laboratory to analyze data collected by Fox Island, LLC and its agents. "The objectives of the analysis are to:

1) Identify the noises that are most bothersome and their sources;
2) Identify possible mitigation options to reduce these noise levels and their related costs; and
3) Present the findings of this research to Fox Island Electric Collaborative (FIEC) and the community in a form that can be understood by as many of the community members as possible". [69]

Data is being collected from nearby residents of the turbines who are self reporting turbine noise in order for researchers to link neighbors' descriptions of sounds with the number of occurrences.

Potential mitigation options at the turbine include the following:

- slowing down the turbines at night;
- increasing the cut-in wind speed;
- adding additional insulation to the nacelle; and
- changing the tip and/or trailing edges of the blade to decrease aeroacoustic sound.[70]

Fox Island, LLC is also exploring "active noise cancellation" technology which could potentially reverse the sound waves in homes located closest to the turbines. In the case of Vinalhaven six homeowners have complained strongly about the turbine noise with another dozen neighbors within three-quarters of a mile from the turbines unhappy with the noise.

Rollins Mountain
The 60 MW, 40-turbine project located near the Lincoln area of Penobscot County was permitted in April, 2009. Developed and owned by First Wind, the project is currently under construction.

[69]National Renewable Energy Lab, "Action Plan for Investigating Noise Issues at Fox Islands Wind Project", September 23, 2010, Pg. 1
[70]National Renewable Energy Lab, Pg. 1

The Rollins project is important to note because the developer and the DEP worked together, having learned from past experiences at Mars Hill, Vinalhaven and emerging literature on the subject and were very sensitive to the potential sound issues from the project.

A protocol was developed that required specific measurement conditions for greatest wind turbine sound production, most favorable sound propagation conditions and specific meteorological and acoustical measurement parameters.

These protocol conditions necessitate conservative modeling assumptions, e.g. conservative factors for ground attenuation including:

- treating lakes and ponds as reflective surfaces;
- excluding potential sound attenuation due to foliage; and
- adding 5 dBA to the manufacturer's wind turbine specification and modeling uncertainties.

The sound level assessment that was completed is expected to meet the DEP's sound regulations and actually fall below the requirements.[71]

In addition, Resource Systems Engineering (RSE) recommended the following:

- "Prior to operation of the wind project, RSE recommends monitoring pre-development ambient sound levels at points representing nearby protected locations and during periods representing wind turbine operating conditions. Ambient sound level measurements will provide useful data concerning the contribution of non-turbine sound levels during future operation of the wind project.

- Once construction and startup of the wind project are complete, RSE recommends monitoring sound levels during routine wind project operations to verify compliance with relevant Maine DEP sound level limits."[72]

Oakfield

The 51 MW, 34 turbine project located in Oakfield, Aroostook County developed by First Wind (aka Evergreen) was permitted in January, 2010. This project is interesting to note because the Town of Oakfield formed a "Wind Energy Review Committee" that hired its own attorney and noise consultant who worked with the developer to develop a

[71]Maine Department of Environmental Protection, Rollins' permit application, Section 5 Noise, prepared by Resource Systems Engineering, October 30, 2008, Pgs. 8-9
[72]Rollins Permit Application, Pg. 10

Sound Complaint Response and Resolution Protocol. This Protocol was agreed upon by the developer and is intended to provide "a transparent process for identifying and responding to potential sound complaints, a consistent approach to documenting complaints, a process for the applicant to communicate with the Town and the DEP regarding potential complaints, and flexibility for ensuring appropriate actions are taken in response to potential complaints".

The Sound Complaint Response and Resolution Protocol includes the following:

The applicant proposes to implement a post-construction monitoring protocol consistent with the following:

"Within 12 months from when the project becomes operational, Evergreen shall conduct sound monitoring at two or more representative locations around the project. These locations shall be chosen in consultation with the DEP and the Town based on how well they represent local meteorology and their relative noise impact from the wind turbines (highest potential to exceed the applicable noise standards). In addition, special consideration shall be given to landowners that have registered sound complaints. The April 6, 2009 Rollins protocol shall be followed except that the weather conditions in Section b of the protocol shall be relaxed if certain conditions described in the proposal are met.

iii. The applicant has agreed that if tonal sounds cause an exceedance of Chapter 375.10 sound limits, Evergreen will promptly notify the DEP and the Town. Evergreen will then expedite an investigation of the sound level exceedance and the associated tonal sound and develop a mitigation plan and schedule to achieve compliance with the applicable sound level limits. Evergreen will provide copies of the mitigation plan to the Department and the Town, implement the mitigation plan, and provide a written report describing the actions taken and new measurement results that demonstrate compliance. Mitigation options could include reduction of the overall sound level and/or the tonal sound component. The Department reserves the right to order immediate actions to be taken to mitigate such sounds while this process is taking place, or to take such other enforcement action it finds appropriate.

iv. The applicant has restated its commitment that the project will comply with the 45 dBA quiet nighttime limit during nighttime hours at applicable regulatory locations even if the pre-development ambient sound level is more than 35 dBA. Similarly, the project will comply with the 55 dBA quiet daytime limit during daytime hours at applicable regulatory locations even if the pre-development ambient sound is greater than 45 dBA.

v. The applicant has stated its commitment that any future First Wind wind energy project sited proximate to the project that is the subject of the application will be sited

and operated in a manner to ensure that the combined sound, i.e. the sound associated with the existing project and potential future project, complies with the quiet noise limits at applicable regulatory locations."[73]

Spruce Mountain
The 20 MW, 10 2-MW turbine proposed project, located in Woodstock is being developed by Patriot Renewables. The project received its permit from DEP in October of 2010 and is currently under appeal to the BEP.

The proposed project is worth noting because of a number of actions that will be implemented designed to ensure strict compliance of the Site Location Law's noise regulations. These measures were insisted upon by the DEP and adopted by the developer. These include sound level modeling, compliance monitoring and a complaint protocol. Following are some of the implementation measures included in the permit:

Sound Level Modeling

- Operating a number of turbines in a noise restricted mode during the nighttime hours;
- "Locking" six of the turbines by the manufacturer, Gamesa, to operate the turbines at reduced noise levels;
- Adding an additional 3 dBA to the specified sound power levels of each turbine to allow for uncertainty in the sound propagation modeling calculations;
- Excluding any sound absorption effects from foliage;
- Using sound power emissions as an idealized point source in place of a distributed area source; and
- Assessing data collected from the project site based on the site terrain, expected wind sheer, and expected wind turbulence to determine potential amplitude modulation.[74]

Compliance Monitoring

1. "Compliance will be demonstrated when the required operating/test conditions have been met for twelve 10-minute measurement intervals at each monitoring location.

[73]Department of Environmental Protection, Oakfield Department Order, January, 2010, Pgs. 8-9
[74]Maine Department of Environmental Protection, Spruce Department of Environmental Protection, Oakfield, Department Order, January, 2010 Pgs. 8-9Mountain, Department Order, October, 2010, Pgs. 7-11

2. Measurements must be obtained during weather conditions when wind turbine sound is most clearly noticeable, i.e. when the measurement location is downwind of the development and maximum surface wind speeds are less than or equal to 6 mph with concurrent turbine hub-elevation wind speeds sufficient to generate the maximum continuous rated sound power from the five nearest wind turbines to the measurement location. [Note: These conditions occur during inversion periods, usually between 11:00 p.m. and 5:00 a.m.] Measurement intervals affected by increased biological activities, leaf rustling, traffic, high water flow or other extraneous ambient noise sources that affect the ability to demonstrate compliance must be excluded from reported data. The intent is to obtain 10-minute measurement intervals that entirely meet the specified criteria. A downwind location is defined as within 45° of the direction between a specific measurement location and the acoustic center of the five nearest wind turbines.

3. Sensitive receiver sound monitoring locations must be positioned to most closely reflect the representative protected locations for purposes of demonstrating compliance with applicable sound level limits, subject to permission from the respective property owner(s).

4. Meteorological measurements of wind speed and direction must be collected using anemometers at a 10-meter height above ground at the center of large unobstructed areas and generally correlated with sound level measurement locations. Results must be reported, based on 1-second integration intervals, and be reported concurrently with hub level and sound level measurements at 10 minute intervals. The wind speed average and maximum should be reported from surface stations. Department concurrence on meteorological site selection is required.

5. Sound level parameters reported for each 10-minute measurement period must include A-weighted equivalent sound level, 10/90% exceedance levels and ten 1-minute 1/3 octave band linear equivalent sound levels (dB). Short duration repetitive events should be characterized by event duration and amplitude. Event frequency is defined as the average event frequency +/- 1SD and amplitude is defined as the peak event amplitude minus the average minima sound levels immediately before and after the event, as measured at an interval of 50 ms or less, A-weighted and fast time response, i.e. 125 ms. For each 10-minute measurement period, short duration repetitive sound events must be reported by percentage of 50 ms or less intervals for each observed amplitude integer above 4 dBA. Reported measurement results must be confirmed to be free of extraneous noise in the respective measurement intervals to the extent possible and in accordance with paragraph 2 above.

6. Up to three compliance locations must be determined in consultation with the Department and be fully operational prior to commissioning of the facility."[75]

Compliance data outlined above must be submitted to the DEP no later than six months after commencement of operation unless additional time is granted. Compliance data must also be submitted for review and approval annually for the first 5 years of operation and then once every five years until the project is decommissioned.

Complaint Protocol

- Establishing a permanent compliance monitoring station at each of the compliance locations approved by the DEP.

- Collecting compliance at each of the approved locations 24 hours per day, 7 days per week during all periods when the facility is in operation beginning on the first day of operation and continuing until the decommissioning of the facility.

- Establishing a toll free complaint hotline designed to allow concerned citizens to call in a noise related complaint 24 hours per day, 7 days per week. The hotline number must be clearly noticed to all abutting property owners and posted in prominent locations around the project site and within the town of Woodstock municipal offices.

- Responding to a complaint within 48 hours of receipt of the complaint, collecting the complainant information (name, location, time of complaint etc.) and the recorded sound, meteorological and operational data from the appropriate compliance monitoring location, and submit that information to the Department for analysis.

- The Department will screen the complaints and send those that indicate the potential for non-compliance with the terms and conditions of this Order to a third-party sound consultant contracted by the Department specifically for the review of noise related complaints. The applicant will be responsible for the reimbursement of all costs incurred by the Department in the review of any noise related complaint.[76]

Wind Energy Development Projects Located in the LURC's Jurisdiction
LURC's jurisdiction consists of the unorganized and deorganized areas of the State and plantations and towns that choose not to do their own planning and zoning.

[75]Maine Department of Environmental Protection, Spruce Mountain Department Order, October, 2010 Pgs. 13-15
[76]Maine Department of Environmental Protection, Spruce Mountain Department, Order Pg. 15

Approximately one-third of LURC's jurisdiction has been designated as expedited permitting areas for wind energy development. The DEP's Chapter 375 Site Location Law's noise regulations apply to LURC wind energy development projects located in the expedited permitting areas. The LURC's Chapter 10 noise standards are applicable to projects NOT located in the expedited permitting areas, and to projects that do not meet the definition of "wind energy development", such as projects that are smaller than 100 kW.

Stetson I
The Stetson I project, a 57 MW project with 38- 1.5 MW turbines is located in Washington County (near Danforth) was developed by First Wind. This was the first wind energy development project approved and constructed in LURC's jurisdiction. This project followed LURC's Chapter 10 Noise rules, as it was approved prior to the Wind Power Development Act.

Kibby I
Kibby I, a 132 MW project located in Kibby Township and Skinner Township, Franklin County, was developed and constructed by TransCanada. The timeframe during which this project was reviewed by LURC straddled the April 18, 2008 enactment of the Wind Power Development Act and the application of DEP's Site Location Law's noise regulations to wind energy developments in the expedited permitting area. At that time, LURC's process involved two steps – first a rezoning, followed by a development permit. Although the Kibby I development permit application was accepted for processing by the LURC on April 22, 2008, the project review was initiated as a rezoning petition under the pre-Wind Power Development Act rules. The Kibby I project was constructed and became operational in two equal sized phases (A Series and B Series) and consists of forty-four, 3 MW turbines, for a total of 132 MW. This project was reviewed under the LURC's Chapter 10 Noise rule, but also met the provisions of DEP's Site Location Law's noise regulations.

Kibby II
Kibby II, a proposed project to be located in Chain of Ponds Twp. and Kibby Twp., Franklin County, with a proposed additional 11-3 MW turbines, for a total of 33 MW, falls under DEP's Site Development Law's noise regulations and was permitted on January 5, 2011. (The rule-making to expand the expedited permitting area for a proposed Kibby III project was withdrawn by the developer.)

Stetson II
Stetson II, a 25.5 MW project with 17-1.5 MW turbines is located in Washington County, and was developed by First Wind. Stetson II was the first wind energy development project located in LURC's jurisdiction reviewed under the DEP's Site Location Law's noise regulations. The Stetson II project led to the protocol used for the Rollins project

which was also adopted by the Oakfield project (discussed earlier) to determine sound level testing and compliance monitoring. The sound testing protocol that was developed included sound level measurement results for twelve 10-minute measurement periods meeting precise testing conditions, instead of quarterly testing that has been the norm with other projects in Maine. The Sound Testing Protocol for Stetson II Wind included the following:

- "Measurements will be obtained during weather conditions when wind turbine sound is most clearly noticeable, usually during nighttime inversion periods;
- Measurement intervals influenced by increased biological activity, leaf rusting, traffic, high water flow or other extraneous ambient sounds that affect the ability to demonstrate compliance will be excluded from the reported data;
- Sound monitoring locations will be position to most closely reflect representative protected locations for purposes of demonstrating compliance with applicable sound level limits; and
- Meteorological measurements of wind speed and direction will be collected using anemometers at a height of 10 meters above the ground. Results will be reported based on 1-second measurement intervals and synchronously with wind turbine power output and sound level measurements at 10-minute intervals."[77]

Currently, there are no results from the Sound Testing Protocol but they are expected to be submitted to LURC shortly.

It should be noted that none of the projects located in LURC's jurisdiction have had noise complaints. These projects are located in relatively isolated areas, and are generally farther from residential areas than the projects that are located in DEP's jurisdiction. It should be noted, however, that the LURC currently has three proposed wind power development projects within their jurisdiction that are somewhat close to residences, in one case, one-half mile in distance.

VII. Opportunity for Public Hearing

Maine DEP's Process for Public Involvement

The DEP Site Location Law does not require a public hearing. A public hearing can be requested of the DEP by a member of the public. The existing test in granting such a hearing is that new or conflicting technical information must be presented in relation to

[77] Bodwell, Scott, Stetson II Wind Project Sound Testing Protocol, March 15, 2010, Pg. 2

the developer's wind energy development proposal. Public hearings have been requested numerous times of the DEP but to date, none have been granted.

The Site Location Law does require that a "public informational meeting" be held and staffed by the developer in the local community where a wind energy development project has been proposed. An applicant must hold the public informational meeting prior to filing an application. The public informational meeting is noticed 10-days prior to the meeting to abutters and to the municipality by certified mail and in a newspaper of general circulation in the area where the development is to be located. Meetings are held in the evening to ensure maximum participation. The intent of the public informational meeting is to provide an open forum for the public to address the developer directly with questions and concerns regarding the proposed wind energy project.

In order to provide direct public input on a pending application during the review of the permit application the DEP then holds a public meeting where members of the public have the opportunity to ask questions of DEP staff and review agents regarding the proposed wind energy project. DEP staff take written notes and an audio recording of the meeting which becomes part of the licensing record for the project. All questions are addressed in the Department Order or in writing in a Q&A document that is circulated to all interested parties.

The difference between a public hearing and a public information meeting is that a public hearing would include sworn testimony, cross-examination of witnesses would occur, and would be overseen by a public hearing officer. It is also important to note that it would be more costly for DEP to run public hearings due to additional expenses related to administration of the hearing process.

Maine Land Use Regulation Commission's Process for Public Involvement

When a wind energy development proposal (and all other proposals) is under LURC's jurisdiction, LURC's Chapter 4 "Rules of Practice", and Chapter 5, "Rules for the Conduct of a Public Hearing" apply. A public hearing can be requested by an interested party on a proposed project by submitting evidence and information related to the proposed project to the LURC. The LURC is required to consider all requests in a timely manner and to "consider the degree of public interest and the likelihood that information presented at the hearing will be of assistance to the LURC in its decision" to grant a public hearing. Public noticing of public hearings is required. When a public hearing is not granted by the LURC, interested parties may submit written comments to the LURC.[78] (LURC staff is currently drafting proposed revisions to this rule.)

[78] Maine Land Use Regulation Commission, Chapter 4 Rules of Practice, Pgs. 5-6

For expedited wind energy development applications, the time frames for processing are the same as for DEP – 185 days if no hearing is held and 270 days if there is a hearing. For all other wind energy developments, a rezoning is required and time frames are likely to be longer than for the expedited area, with no specific maximum.

The LURC has held public hearings for each of the wind energy development projects permitted in their jurisdiction, with the exception of the Stetson II project.

Other Jurisdictions' Public Meeting Policies

Oregon
An optional "informational meeting" can be held early on in the state's review process but a public hearing is required later in the process before a final decision on siting is made. Written or oral comments must present facts that support the person's position on the issue.

Massachusetts
Massachusetts does not have a state public hearing process for wind energy developments. However, municipalities do hold public hearings on individual wind energy development projects as they go through the permitting process at the local level.[79]

New Hampshire
New Hampshire requires at least one joint public information hearing once a renewable energy facility's application is complete, to be held in each county in which the proposed facility is to be located with a 30-day noticing period. The purpose is to "allow the applicant to describe the nature and location of the proposed facilities to the committee, and to the public and to allow members of the public to raise questions and make comments about the proposal". In addition, an informational meeting is held by the applicant if requested of the local municipality.[80]

Wisconsin
Wisconsin's Public Service Commission's proposed wind siting rules include the following requirements for public participation including a public meeting.

> (a) A political subdivision shall make an application for a wind energy system available for public review at a local library and at the political subdivision's business office or some other publicly-accessible location. A political subdivision may also provide public access to the application electronically.

[79]Broad, Martha, Massachusetts Clean Energy Center, conversation, January 3, 2011
[80]New Hampshire, Chapter Site 200 Practice and Procedure Rules, June, 16 2008

(b) A political subdivision shall establish a process for accepting and considering written public comments on an application for a wind energy system.
(c) A political subdivision shall hold at least one public meeting to obtain comments on and to inform the public about a proposed wind energy system.[81]

VIII. Mitigation of Wind Turbine Noise

Modern turbines are much quieter than their predecessors, however, noise can still be a problem. The first solution is to properly site wind energy development projects with appropriate setbacks and accurate acoustic modeling of sound output in order to avoid complaints. For existing projects that cause complaints from nearby residences, turbines can be put into noise reduction operations (NRO) which is a manufacturer setting that effectively slows down the maximum rotation of the turbine resulting in reduced sound output. Turbines can also be turned off at certain times of the day or night to reduce noise output.

In order for nearby neighbors to accept higher than allowed sound levels, easements are typically executed. Payments are made to nearby neighbors who agree to accept higher levels of sound output from proposed projects. We have learned that easements in Maine are typically around $1,000 per landowner. Although in July, 2010 the New York Times reported that wind developer Caithness Wind, LLC that is developing a project in Oregon was offering waivers for $5,000.[82]

In some cases homes are purchased by developers from complaining neighbors who do not wish to continue living near wind turbines. There are not a lot of published examples of this type of financial mitigation or transactions, as developers tend to keep such agreements private. But we do know that a variety of easements and buy-outs have occurred in Maine. In Massachusetts, easements are executed in which developers purchase properties and the homeowners agree to vacate the property before the project is built.

Although we could not find a lot of information from the turbine manufacturers on new quieter turbine designs, (see part A of this report on "technology trends") we expect that companies such as General Electric, Vestas and others are working on new quieter wind turbine technologies that will reduce the output of wind turbine noise. We did find reference to a project in Germany in which researchers have developed an "active damping system for wind turbines. These systems react autonomously to any change in

[81]Wisconsin Public Service Commission, Wind Siting Rule, August 31, 2010
[82]Yardley, William "Turbines too loud? Here take $5,000" New York Times, July 31, 2010

frequency and damp the noise — regardless of how fast the wind generator is turning. The key components of this system are piezo actuators".[83]

"These devices convert electric current into mechanical motion and generate 'negative vibrations', or a kind of anti-noise that precisely counteracts the vibrations of the wind turbine and cancels them out. The piezo actuators are mounted on the gearbox bearings that connect the gearbox to the pylon. They have integrated sensors into the system. They constantly measure the vibrations arising in the gearbox, and pass on the results to the actuator control system. The researchers have already developed a working model of the active vibration dampers, and their next step will be to perform field trials."[84] We fully expect new technologies like the one described above to be developed and employed in wind energy developments.

As discussed previously, there are a number of noise mitigation measures being explored at the operational Vinalhaven project in Maine. Wind turbine manufacturers are in the process of developing software systems that can actively manage turbine operation based on a wide variety of weather conditions. Currently NRO software only considers a single set of weather conditions and is not related to the variety of conditions that are now currently known to affect to noise generation. For example there are several different wind direction and atmospheric conditions which vary at both ground level and turbine height that contribute to exceedances of noise limits. Current NRO software cannot manage this variety of conditions and tell the turbines how to operate at hub height based on wind and atmospheric conditions at ground height. Wind turbine developers are working on software modifications that will significantly improve the operational flexibility of turbines. This will be an important additional tool for noise mitigation where it is needed.

IX. Human Perception of Noise and Annoyance

Public Support for Wind Energy

Public support for wind energy and other forms of renewable energy is generally high. For example in May of 2010, Maine statewide public support for wind energy development was 88%. In Maine's "rim counties" where wind energy development is more likely to occur, support was 83%.[85] The reasons for support of wind energy development in Maine (and typically in other areas) include the following:

- Reduction of dependence on fossil fuels

[83]Fraunhofer-Gesellschaft, "Anti-Noise Silences Wind Turbines", Environmental News Network, http://www.enn.com/sci-tech/article/37894 August 11, 2008, Pg. 1
[84]Fraunhofer-Gesellschaft, Pg. 1
[85]Pan Atlantic SMS Group "Report to Maine Renewable Energy Association Highlights of Survey Findings", May 2010, Pg. 3

- Creation of jobs and other economic benefits, especially in rural areas
- Generation of renewable energy
- Reduction of greenhouse gas emissions that contribute to global warming
- Reduction of industrial pollution from power plants in the region
- Creation of additional economic opportunities[86]

However, the closer one lives to an actual wind energy development, support can erode. Of the 2.3% of Maine residents who oppose wind energy, the biggest reason cited was noise.[87]

Perception

Perception of noise is different for different people and people's responses to different kinds of noise varies. Neighbors living close to wind turbines can have different perceptions and reactions to the noise than other neighbors in the same vicinity. This is particularly true in rural areas in which perception of the rural setting can either be a place of a restorative nature compared to a place where economic activity takes place.

How much a person will be annoyed from noise depends on a number of factors related to perception and a person's attitudes. The following is a list of factors influencing the degree of annoyance to noise developed by Findell and Stallen in 1999:

- "Perceived predictability of the noise level changing
- Perceived control, either by the individual or others
- Trust and recognition of those managing the noise source
- Voice, the extent to which concerns are listen to
- General attitudes, fear of crashes and awareness of benefits
- Personal benefits, how one benefits from the noise source
- Sensitivity to noise
- Home ownership, concern and plummeting house values
- Accessibility to information relating to the noise source

To which may be added:

- Perceived value of the noise source
- Expectation of peace and quiet
- Visual impact"[88]

In addition, "the perception of noise depends in part on the individual—on a person's hearing acuity and upon his or her subjective tolerance for or dislike of a particular type

[86]Pan Atlantic SMS Group, Pgs. 4-5
[87]Pan Atlantic SMS Group Pg. 7
[88]Hanning, Christopher "Wind Turbine Noise, Sleep and Health", April, 2010, Pg. 12

of noise. For example, a persistent "whoosh" might be a soothing sound to some people even as it annoys others. Nevertheless, it appears that subjective impressions of the noise from wind turbines are not totally idiosyncratic. A 1999 study (Kragh et al. 1999) included a laboratory technique for assessing the subjective unpleasantness of wind-turbine noise. Preliminary findings indicated that *noise tonality* and *noise-fluctuation strength* were the parameters best correlated with unpleasantness (Kragh et al. 1999)".[89]

Annoyance from Wind Turbines

Annoyance, caused from noise, is the biggest complaint as a result of wind energy developments. There are other complaints such as aesthetics, a drop in property values, impacts to wildlife, industrialization of wilderness areas, cost of renewable power, and others, but noise is the dominant complaint.

However, complaints about wind energy developments in the U.S. due to noise impacts are rare, 5-10% at most.[90] This doesn't mean people have not been impacted. People have been and continue to be negatively impacted as a result of noise from wind turbines placed near their homes. Although, only about a dozen or so out of the approximately four hundred wind energy developments in the U.S. "have spurred significant noise issues".[91]

Two of these projects are located in Maine. Both the Mars Hill and Vinalhaven projects have resulted in considerable noise complaints from a small number of nearby residents and have generated many national press stories about the projects. The turbine setbacks for both of these projects are less than one-half mile in distance. "Noise produced by wind turbines generally is not a major concern for humans beyond a half-mile or so because various measures to reduce noise have been implemented in the design of modern turbines."[92]

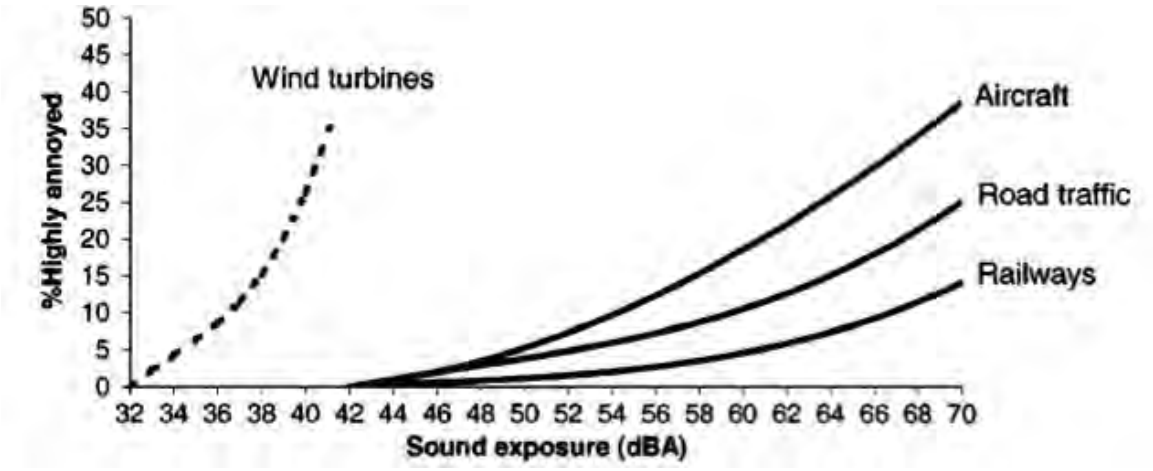
Wind turbine noise appears to be more annoying at lower dB levels than other types of sounds due to several potential factors such as:

- Low frequency vibrations;
- Repetitive whooshing (amplitude modulation);
- Variations in the noise (compared with constant noise such as highway traffic noise)[93]
- Wake Induced noise[94]

[89]National Academy of Sciences, "Environmental Impacts of Wind-Energy Projects", 2007, Pg. 157
[90]Cummings, Jim "Wind Farm Noise Public Perception and Annoyance", Acoustic Ecology Center, Power point presentation
[91]Cummings, Jim "Wind Farm Noise: 2009 in Review", Acoustic Ecology Center, Pg. 5
[92]National Academy of Sciences, Pg. 159
[93]Minnesota. Public Health Impacts of Wind Turbines, Department of Health Environmental Division, 2009, Pg. 15

"Several studies have now shown that annoyance curves for other noise sources are not applicable to wind turbine noise: around wind farms, equivalent levels of annoyance are triggered by much lower noise levels".[95] In fact, "moderate wind farm noise seems to trigger more than twice the annoyance caused by other typical noise sources, even when statutory noise limits are met.[96]

Figure 11: Annoyance associated with exposure to different environmental noises (Source: Pederson and Waye, 2004)



Pederson and Waye have conducted a number of studies over the years by surveying residents near wind energy developments in Scandinavia. Their latest work, completed in June of 2009 draws from almost 1,800 people from three different wind energy developments.

"The heart of the studies shows a correlation between sound level and annoyance, with an increasing percentage of people annoyed as noise levels increase. This effect was clearly stronger in the two flat, rural areas, than in a study that took place in a suburban, rolling landscape that had more other noises present.
A dramatic increase in the proportion of people annoyed by turbine noise took place when the noise was over 40 dB(A); here, 25-45% reported annoyance in rural settings, and 10% in the suburban area. At 35-40 dB, annoyance ranged from 16-20% in rural settings but was only 5% in suburban; at 30-35 dB, annoyance hovered around 10% in rural areas.[97]

[94]Shepard, Ian "Wake Induced Noise", Pg. 2
[95]Pedersen, E. and K.P. Waye, "Perception and annoyance due to wind turbine noise—a dose–response relationship" The Journal of the Acoustical Society of America, 2004
[96]Cummings, Jim, Powerpoint presentation
[97]Cummings, Jim, Pg. 14

Key: ***Maroon (center) bars are the suburban site; purple and yellow are rural sites. SWE-00 = Sweden, 2000 SWE-05 = Sweden, 2005 NL-07 = Netherlands, 2007 Purple = Rural locations, mostly flat, N=351 Maroon = Mostly suburban, varied topography, N=754 Yellow= Mostly rural, mostly flat, N=621***

Figure 11: Percentage of people that can hear the turbines at each sound level (Source: Pederson and Way, 2009)

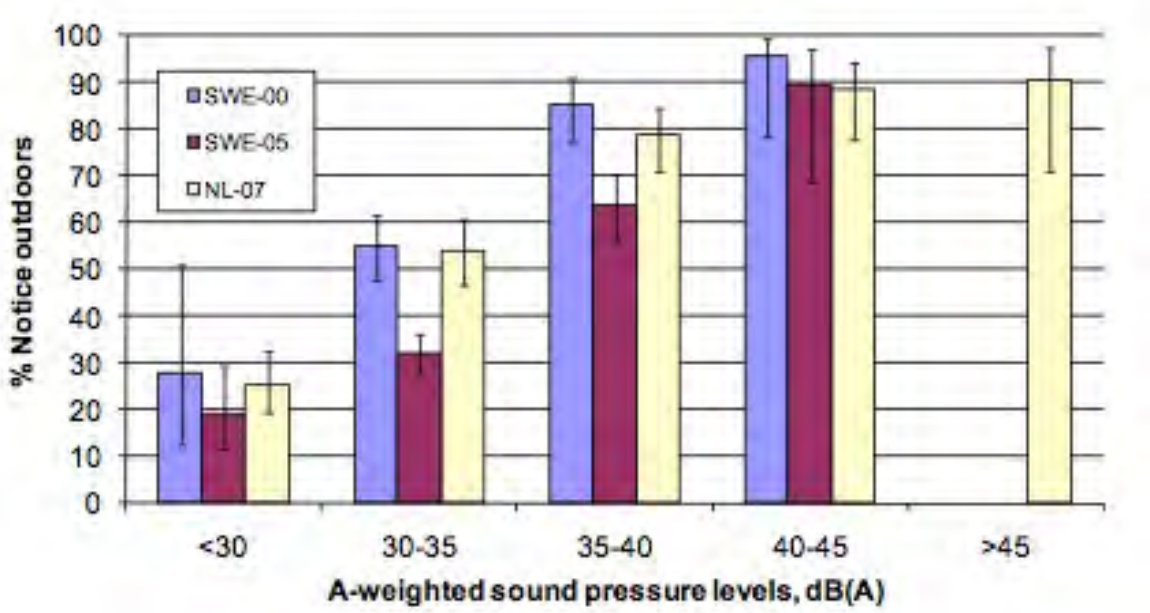
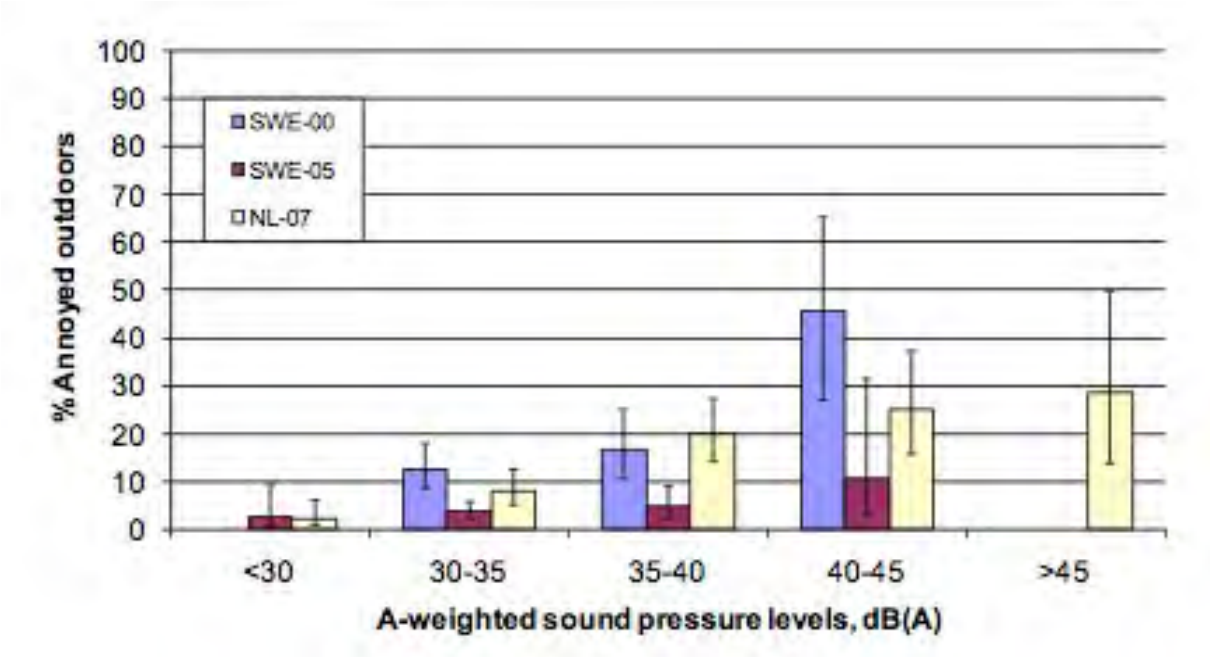


Figure 12: Percentage of people that are "rather" or "very" annoyed at each sound level. (Source: Pederson and Waye, 2009)



Annoyance Trends

Being annoyed doesn't necessarily mean that a person is constantly annoyed. For a number of people, "annoyance is occasional and temporary." Of the 5-40% of people who report annoyance at various sound exposures the following is true:

- 50% are disturbed just once or twice a week;
- 25% are disturbed daily or nearly daily;
- 50% are only bothered outside;
- 50% are bothered outside and inside; and
- 1/3 or less of those annoyed report physical or health effects including sleep disruption.

Annoyance is strongly associated with the following considerations:

- When wind turbines are visible
- When a person has strong negative attitudes toward wind turbines
- When wind turbine noise is over 40 dB
- How a person views the rural lifestyle and landscape (restorative vs. economic activity)[98]

[98]Cummings, Jim Powerpoint Presentation

Noise Sensitivity
While perception affects the degree to which noise can be annoying to a person, a certain percentage of the population is actually "noise sensitive", which is a characteristic a person cannot generally change or control. Much research has been carried out since the 1970's on the impacts of noise on the population. It has been found that 20% of the population is "noise sensitive", 50% of the population is "noise tolerant", and 30% of the population is "moderately noise sensitive." [99]

The literature is clear that only a minority of people are highly sensitive to, or negatively affected by, wind turbine noise. Typically, between 5-20% of people, with higher levels of around 20% of people in rural areas, are highly annoyed by wind turbine noise.[100] These figures correspond to the figures cited above for general types of noise impacts on the general population.

X. Potential Health Impacts of Wind Turbine Noise

Disagreement on Health Impacts from Wind Turbine Noise
There is disagreement from supporters and opponents of wind energy development on whether wind energy noise and/or vibration causes health impacts and/or disease. It is clear through numerous documented complaints in the U.S. and other countries that some people living near wind turbines self-report that they are negatively affected by wind turbine noise, particularly through sleep disruption, although it has also been noted that sleep disruption is also common in the general population.

There is no question that chronic exposure to high levels of sound such as jet engines or workplace industrial noise are linked to health impacts. "At high level noise exposure of 70 dBA and above evidence of direct physiological effects, hearing loss and altered function of cardiovascular and endocrine systems ensue."[101] There has been much research on industrial noise. However, while there is some bona fide research on the health effects of wind turbines "there is not an extensive amount of research specifically on the health effects related to the sound exposure generated by wind turbines."[102]

Current Scientific Thinking
There are several recent analyses of the research on health effects from wind turbines by a variety of government health departments which conclude that wind turbine noise does

[99]Cummings, Jim, Powerpoint presentation
[100]Cummings, Powerpoint presentation
[101]McFadden, Jevon, "Wind Turbines: A Brief Health Overview", Powerpoint presentation to Wisconsin Wind Siting Council, May 17, 2010
[102] Mark Roberts, M.D. and Jennifer Roberts, "Evaluation of the Scientific Literature on the Health Effects Associated with Wind Turbines and Low Frequency Noise", October 20, 2009, prepared for Wisconsin Public Service Commission, Pg. 42

not cause disease or health problems, but can create annoyances. For example, in a July 2010 report, Australia's National Health and Medical Research Council concluded that "there is no evidence that wind turbines have a direct effect on human health."[103] In a May 2010 report, Chief Medical Officer of Health in Ontario has concluded that "while some people living near wind turbines report symptoms such as dizziness, headaches, and sleep disturbances, the scientific evidence available to date does not demonstrate a direct causal link between wind turbine noise and adverse health effects.[104]

However, Dr. Carl Phillips has concluded that "there is ample scientific evidence to conclude that wind turbines cause serious health problems for some people living nearby." [105] Dr. Mark Roberts and Dr. Jennifer Roberts concluded that as of their review, "there has not been a specific health condition documented in the peer reviewed published literature to be classified as a disease caused by exposure to sound levels and frequencies generated by the operation of wind turbines. That does not mean that there cannot be an effect."[106]

In addition, Dr, Eja Pedersen from the Swedish environmental health agency has found in her research of noise on people living near wind turbines "the main adverse effects was annoyance due to the sound; the prevalence of noise annoyance increased with increasing sound pressure levels. Disturbance of sleep was furthermore related to wind turbine noise; the proportion of residents reporting sleep disturbance due to noise increased significantly at sound levels close to those recommended as highest acceptable levels at new (wind energy) installations. No other clear associations between sound levels and self reported health symptoms have hitherto been found. However, noise annoyance was correlated with several measurements of stress and lowered well being. The study does now allow for causal conclusions, but the association indicates a possible hindrance of psycho-physiological restitution. Such a hindrance could in the long term lead to adverse health effects not detected here."[107]

Some wind energy opponents claim that wind turbine noise causes certain diseases such as "wind turbine syndrome", "vibroacoustic disease" as well as "visceral vibratory vestibular disturbance". [108] However, these diseases are not accepted by the medical community but are looked upon as hypotheses that are not scientifically proven.

[103]"No Link Between Wind Turbines and Health: Report," July 5, 2010, www.RenewableEnergyFocus.com
[104]Ontario, Chief Medical Officer of Health , The Potential Health Impact of Wind Turbines, Pg. 10
[105]Phillips, Carl M.D. "An Analysis of the Epidemiology ad Related Evidence on the Health Effects of wind Turbines on Local Residents", prepared for Wiisconsin Public Service Commission, July 3, 2010, Pg. 2
[106]Roberts, Mark, Pg. 7
[107]Peterson, Eja Dr., "Effects of Wind Turbine Noise on Humans", Third International Meeting on Wind Turbine Noise, June 2009, Pg. 1
[108]McFadden Powerpoint

Peer Review and Scientific Threshold

In order to prove cause and effect related to any health issue the scientific threshold is quite high and for good reason. The process for publishing, peer-reviewed studies is onerous. According to the Centers for Disease Control and Prevention (CDC) the peer-review process is an "independent assessment of the scientific merit of research by panels of experts who provide written assurance that their reviews are free of real or perceived conflicts of interest. Results of the peer review process should therefore be without inherent bias and can be viewed as fair and just (CDC 2009)."[109] What this means is that the process is blinded such that the authors and reviewers are not identified to each other, and the process is conducted by an objective third party "The key aspect of the peer review is a critical appraisal of the research, a continuous challenge of the scientific hypothesis and comparison with the body of scientific knowledge relevant to research".[110]

In reviewing the literature on wind turbine noise research it should be noted that some of the studies and articles lack one or more of the following characteristics and are often discounted by other researchers and other parties for their failings. These shortfalls include: a lack of recommendations and findings based on literature reviews; lack of published, scientific peer-reviewed articles; self-publishing, reliance on case studies; lack of a control group; and using subjects that self-report and relying on a very small number of subjects for study

A major question remains, whether "annoyance is associated with long-term adverse health effects? Consider the following:

- It has been shown that chronic annoyance may contribute to stress-related illness after long term exposure.
- It is unknown to what extent chronic annoyance can actually be measured. There is no consensus on how chronic annoyance and stress-related illness might be quantitatively related.
- There is no consensus on how chronic annoyance and stress-related illness might be quantitatively related."[111]

World Health Organization

When considering "health impacts" it is also important to define how health is defined. The definition of "health" according to the World Health Organization (WHO) is "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."[112]

[109]Roberts, Pg. 13
[110]Roberts, Mark and Jennifer pg. ?
[111]McFadden, Jevon , Wisconsin Wind Siting Council, Powerpoint, May 17, 2010
[112]WHO Night Noise Guidelines for Europe, 2009, Pg. vii

The WHO's recommendations for health protection for nighttime noise levels are as follows:[113]

> Below the level of 30 dB $L_{night,outside}$, no effects on sleep are observed except for a slight increase in the frequency of body movements during sleep due to night noise. There is no sufficient evidence that the biological effects observed at the level below 40 dB $L_{night,outside}$ are harmful to health. However, adverse health effects are observed at the level above 40 dB $L_{night,outside}$, such as self-reported sleep disturbance, environmental insomnia, and increased use of somnifacient drugs and sedatives.
>
> Therefore, 40 dB $L_{night,outside}$ is equivalent to the lowest observed adverse effect level (LOAEL) for night noise. Above 55 dB the cardiovascular effects become the major public health concern, which are likely to be less dependent on the nature of the noise. Closer examination of the precise impact will be necessary in the range between 30 dB and 55 dB as much will depend on the detailed circumstances of each case.

The WHO has also expressed concerns about low-frequency sound saying that "the evidence on low frequency noise is sufficiently strong to warrant immediate concern…low frequency-noise may also produce vibrations and rattles as secondary effects. Health effects are estimated to be more severe than for community noises in general."[114] It is important to keep in mind that wind turbines generally have very low levels of infrasound and low frequency noise compared to other industrial noise sources and that these comments were not written with wind turbine noise in mind. It is also important to keep in mind that the WHO 2009 report is focused on nighttime noise sources such as from traffic and neighbors, and does not address wind turbines directly.

Sleep Disturbance

Sleep disturbance is the biggest complaint from wind turbine noise and has been recognized in the literature. The WHO's Nighttime Noise Guidelines for Europe working group is in agreement that "there is sufficient evidence that night noise is related to self-reported sleep disturbances".[115]

Some claim the problem is worse than it appears. According to Dr. Christopher Hanning, an expert in sleep medicine "all government and industry sponsored research in this area has used reported awakening from sleep as an index of the effects of turbine noise and

[113]WHO Night Noise Guidelines for Europe, 2009, Pg. xvi
[114]WHO, Community Noise Guidelines, 1999
[115]WHO Night Noise Guidelines for Europe, pg. xii.

dismisses the subjective symptoms. Because most of the sleep disturbance is not recalled, this approach underestimates the effects of wind turbine noise on sleep."[116]

Although a cause and effect relationship of direct health impacts from wind turbine noise has not been scientifically proven communities living near existing or proposed wind energy developments continue to have concerns and governments continue to investigate potential public health impacts. It is clear that additional research needs to be undertaken.

XI. Summary Conclusions and Recommendations

General Conclusions

Maine is not in a unique situation compared to other U.S. states and other countries around the world that have wind energy developments in operation or under development. Public opinion polls are generally highly supportive of wind energy development for its clean renewable power and contributions to reducing greenhouse gas emissions and improving local economies. However, support for wind energy is highly subjective. In fact, the closer people live to the wind energy projects themselves, support declines. Overall, complaints are uncommon but still exist for a small number of projects and are often opposed quite strongly. In response, opposition groups have organized in Maine and throughout the U.S. as well as other countries.

Maine currently has six grid-scale wind energy developments in operation, one under construction and numerous others permitted or under development. It is clear that the DEP and LURC, working with the state's sound consultant and other developers, have learned from past experiences and have begun to adopt 'best practices" that have been developed over the last several years. This experience has proven valuable and should help guide the permitting process in the future.

Acoustical engineering overall including sound propagation modeling, sound level measurement and compliance monitoring are complex and highly technical. It appears that there are several opportunities where assumptions can be made which can affect a project's overall expected sound levels. It is also clear that certain types of noise, namely amplitude modulation and perhaps others, are not adequately considered in international noise standards, sound level computer modeling or the state's current noise regulations. These deficiencies should be addressed by tweaking the state's noise regulations to compensate for these considerations.

Annoyance from turbine noise appears to be the biggest complaint as a result of wind energy developments and prompts complaints, although there are certainly other concerns such as aesthetics, cost of energy, development in wilderness areas, etc. Perception and

[116]Dr. Christoper Hanning, "Wind Turbine Noise, Sleep and Health" April, 2010 Pg. 13

attitudes toward wind energy in general tend to affect the level of annoyance of wind turbine noise. The minority of people who are extremely annoyed from wind turbine noise tend to be staunchly opposed to wind energy development and may experience overall health impacts caused from sleep disturbance as a result of the noise. However, there are many instances in which people were supportive of a wind energy project until the turbines are operating and they are surprised to find that the noise is bothersome. In addition, the literature seems to suggest that wind turbine noise appears to be more annoying than other traditional sources of noise such as traffic, trains, industrial facilities, airports, etc.

While the majority of people living near wind energy developments appear to not be bothered by the wind turbines, people's reactions vary, and a minority of people can be highly annoyed by the noise emitted from wind turbines. It has been shown that this is particularly true in rural areas where residents are used to a lower ambient background noise level (pre-construction) than those living in more industrial or urban areas. Although much of the population lives in areas in which the noise levels are higher than those emitted from wind turbines, these aren't typically the areas in which wind energy developments are sited, which can cause conflicts. In Maine, there have been numerous noise complaints about several projects from nearby neighbors, most notably in Freedom, Mars Hill and Vinalhaven.

There is not a lot of available information in the literature about developers' noise mitigation or financial mitigation strategies. In some cases easements are negotiated prior to project development in which nearby neighbors receive payments for agreeing to live with higher than accepted noise levels. In others, entire properties are purchased and neighbors agree to move out of their homes. Turbine manufacturers are reluctant to share information about new, quieter turbine technologies they are developing. As was discussed in the Vinalhaven project, there are some noise mitigation strategies that are currently being explored.

Of the minority of complaints stemming from wind energy developments, it is common for complaints to focus on infrasound and low frequency sound from nearby residents. Some experts argue that these annoying sounds are actually amplitude modulation and not infrasound or low frequency noise. There are discrepancies in the literature from experts on the potential health impacts of these sounds but it is generally accepted that infrasound at high dB levels may have some overall health impacts. It is the low frequency sounds from wind turbines, that often cannot even be measured, that has generated concern from those opposing wind projects.

There is no epidemiological evidence or a direct cause and effect to support the theory that wind turbines cause health problems or diseases from their noise emissions. However, it is well documented that some people living near wind turbines do self report

a number of overall health related effects. They report that these health effects are thought to be mostly brought on from sleep disturbance attributed to wind turbine noise. They also report that certain vulnerable groups such as children, the elderly and those with existing health conditions seem to be affected the most severely.

Maine's Noise Regulations

Maine's noise regulations are similar in both process and substance to those in other U.S. states and countries. Many U.S. states and other countries use a set decibel level in their standard as Maine does. OEIS finds that the devil is in the details. Set decibel level standards may not always be as accurate as expected because it depends on the metrics or time period over which noise levels are measured as well as the sound propagation model used which can be affected by a variety of terrain and atmospheric conditions. It is possible that using such set decibel levels and differing propagation models could result in sound levels higher than manufacturer's expectations. In addition, the IEC standards do not take into account wind shear in a stable atmosphere which can further lead to higher than expected sound levels which lead to noise complaints.

In reviewing a variety of other jurisdiction's noise regulations, we also found that there is no specific agreed upon standard for either a set decibel level standard or set decibel level over ambient ground noise level standard. Although the noise regulations we reviewed were similar, there is no absolute industry standard that we can look to in order to guarantee avoiding noise complaints from nearby neighbors of a proposed or operating wind energy development. There is much debate over this.

In reviewing the various U.S. states' and international noise standards there are a number of differences in the various noise regulations. These including the following:

- Some noise standards are defined by local municipalities.
- Some noise standards are defined by state law or regulation.
- Some noise standards cover wind energy development projects only, while others include wind energy development along with other types of industrial development.
- Some noise standards have a fixed dB level during the day or night or both (such as Maine).
- Some noise standards use an ambient background noise level (pre-construction) sound measure and allow certain dBs over that limit.
- Compliance monitoring for sound standards vary but usually includes a reference or requirement to adhere to IEC or other international standards.

As mentioned previously, Maine's current standards for "quiet areas" which have applied to all wind energy development projects, except the Mars Hill project, are 55 dBA during

the day and 45 dBA at night and apply to all industrial development projects, not only wind energy development.

OEIS has included several recommendations below on how to improve Maine's existing noise regulations. These recommendations are based on the experiences in acoustic modeling and compliance monitoring from the operational wind energy development projects currently in Maine, those found in the international literature relating to noise studies and from talking to experts in the field. OEIS has attempted to take the lessons learned from these past projects and combine them into a clearer regulation and compliance monitoring protocol that will more accurately take into consideration actual conditions on the ground.

The OEIS recommends the state establish a 1,000 foot minimum setback for wind energy developments from "protected locations" and non-participating residences. Currently, Maine has a safety setback of 1.5 times the height of the turbine which is typically between 582 and 615 feet, depending on the height of the turbine tower. We feel this is not far enough. We understand that setbacks are quite varied, there is no "magic number" that will eliminate noise complaints from a project and that sound attenuates differently depending on topography, atmospheric conditions, etc. However, based on our review of the literature and experiences of other states and nations, the numerous credible complaints from nearby residents of current wind turbines in Maine and our conversations with acoustical experts, we are recommending a 1,000 foot setback for wind energy developments in Maine

Public Hearing

Although we did not perform an exhaustive review, OEIS found that some of the other states we studied do provide for a public hearing while others provide for a public meeting, related to wind energy development projects. It should be noted again that it is currently possible for a public hearing to be held under the existing DEP Site Location Law's regulations and LURC has held public hearings for most of the wind energy projects in their jurisdiction. However, the DEP has concluded that the "test" for such a hearing has not been met for projects in their jurisdiction and no public hearings have been held to date. In addition, the existing regulations do include a public meeting held by the developer and a "public meeting" held by the DEP.

Accordingly, OEIS is recommending that a second "public meeting" be held by the DEP later in the permitting process once the local community and neighbors have had more time to consider the proposed project. This additional "public meeting", while not an adjudicatory public hearing, will provide an expeditious and cost effective second opportunity for the community to express their concerns, ask questions and put their testimony into the record at a later stage in the permitting process.

OEIS is not recommending that a full public hearing be required for each proposed wind energy development project. As noted above, a full public hearing for each proposed project would be administratively more expensive, would unnecessarily extend the permitting time frame and would not coincide with the intent or goals of the Wind Power Development Act. OEIS believes that by providing an additional opportunity for public comment and expert testimony will address most, if not all, of the critical concerns raised by opponents of the current wind developments.

OEIS is recommending that the BEP hold a public hearing as soon as practicable as a result of the recent citizen rulemaking petition which would focus on wind energy development in general and the existing Site Location Law's noise regulations, not on the merits of a specific project. This would provide the much-needed opportunity for the public, both pro and con, to debate and deliberate on the overall issues related to wind energy developments to be considered by the BEP, instead of holding costly and time consuming adjudicatory public hearings for each wind energy project. The intent of this approach is to use past experiences in Maine and elsewhere to improve the existing Site Location Law's noise regulations.

As reviewed earlier, LURC has its own regulations on public hearings related to its noise regulations and, with the exception of Stetson II, has provided for public hearings for each proposed wind energy development project.

General Recommendations

- Requiring developers to inform nearby communities and neighbors living near proposed wind energy projects that operational wind energy developments will produce some noise impacts and are not silent.

- Requiring minimum turbine setbacks of 1,000 feet for non-participating residences and occupied community and residential buildings.

- Passing legislation that allows LURC to require developers to provide reimbursement for sound compliance monitoring as is current policy with the DEP.

- Adding a second DEP "public meeting" in the Site Location Law for proposed wind energy development projects later in the permitting process in order to provide an additional opportunity for the public to share concerns and ask questions regarding proposed projects.

Noise Regulation Recommendations

- Requiring separate noise regulations and procedures for proposed wind energy development projects.

- Making variances inapplicable to wind energy development projects in the Site Location Law.

- Requiring the Board of Environmental Protection to hold a public hearing as soon as is practicable. The purpose is to consider making improvements to the state's existing Site Location Law's noise regulations related to sound level propagation modeling, compliance monitoring and complaint procedures including, but not limited to, the following considerations:

    1. Requiring a "complaint protocol" process, utilizing the Oakfield and Spruce Mountain projects as models, for all future wind energy development projects over 20 MW in size proposed near residential areas.

    2. Requiring compliance monitoring protocols that document the needed duration of monitoring events, the applicable wind conditions and direction for determining compliance including what defines "stable atmospheric conditions", reporting procedures, as well as the evaluation methods to be used by the DEP to determine compliance. It is recommended that the latest compliance protocols issued with the recent projects located at Oakfield and Spruce Mountains serve as the models.

    2. Requiring evaluation of what conditions create wind shear and turbulence at proposed project sites, differentiating between ridgeline and coastal sites, and including these factors in modeling of a proposed wind energy development project's noise impacts.

    3. Including maximum sound power levels irrespective of wind speed in modeling of a proposed project's noise impacts.

Bibliography

Alberts, Daniel, "Primer for Addressing Wind Turbine Noise", Lawrence Technological University, October 2006

Bellhouse, George, "Low Frequency Noise and Infrasound From Wind Turbine Generators: A Literature Review", prepared for Energy Efficiency and Conservation Authority, New Zealand, June 30, 2004

Bodwell, R. Scott, "Stetson II Wind Project Sound Testing Protocol", March 15, 2010

Brown, Warren, "Mars Hill Windfarm Post Development and Sound Level Study Peer Review", November 21, 2007

Brown, Warren, "Mars Hill Windfarm Post Development Third-Quarter Sound Level Study", May 12, 2008

Brown, Warren, "Mars Hill Windfarm Post-Development Quarterly Sound Level Assessment Compilation -- Peer Review", December 8, 2008

Brown, Warren, conversation, November 22, 2010

Bruel and Kjaer, "Environmental Noise Booklet", 2001

Colby, David, Robert Dobie, Geoff Leventhall, David Lipscomb, Robert McCunney, Michael Seilo and Bo Sondergaard, "Wind Turbine Sound and Health Effects: An Expert Review", prepared for American Wind Energy Association and Canadian Wind Energy Association, December 2009

Cummings, Jim, "Wind Farm Noise Public Perception and Annoyance", PowerPoint presentation, The Acoustic Ecology Institute

Cummings, Jim "Wind Farm Noise: 2009 in Review", A special report from the Acoustic Ecology Institute, February 2010

Fraunhofer-Gesellschaft, "Anti-Noise Silences Wind Turbines", Environmental News Network, August 11, 2008

Hanning, Christopher M.D., "Wind Turbine Noise, Sleep and Health", April, 2010

Hayes, Malcolm, "Low Frequency and Infrasound Noise Emissions from Wind Farms and the Potential for Vibrocacoustic Disease", 12th International Meeting on Low Frequency Noise and Vibration and its Control, September 20, 2006

HGC Engineering, "Wind Turbines and Infrasound", submitted to Canadian Wind Energy Association, November 29, 2006

Hoen, Ben and Ryan Wiser, "Assessing the Impacts of Reduced Noise operations of Wind Turbines on Neighbor Annoyance: A Preliminary Analysis in Vinalhaven, Maine", Ernesto Orlando Lawrence Berkeley National Laboratory, June, 2010

International Electrotechnical Commission, home page

Kamperman, George, and Richard James, "Guidelines for Selecting Wind Turbine Sites", Based on a paper presented at NOISE-CON 08, Institute of Noise Control Engineering, Dearborn, MI, July 2008

Lantz, Eric, National Review Energy Lab, "Public Perceptions of Wind Turbine Noise", PowerPoint presentation, October 13, 2010

Larwood, Scott, and van Dam, C. P. (California Wind Energy Collaborative). 2006. *Permitting Setback Requirements for Wind Turbines in California*. California Energy Commission, PIER Renewable Energy Technologies. CEC 500 2005 184

Learn, Scott, Oregonian Newspaper, "Oregon Public Health Decides its Time to Study Health Effects of Wind Turbines", October 21, 2010

Leventhall, Geoff, A Review of Published Research on Low Frequency Noise and its Effects, A report for Defra, May 2003

Leventhall, Geoff, Testimony to the Public Service Commission of Wisconsin, Docket #6630-CE-302

Leventhall, Geoff, "Infrasound from Wind Turbines – Fact, Fiction or Deception", Canadian Acoustics, Vol. 34 No. 2, 2006

Leventhall, Geoff, "Low Frequency Noise. What we know, what we do not know, and what we would like to know", Journal of Low Frequency Noise, Vibration, and Active Control, V. 28 2009

Maine. Department of Environmental Protection, Rollins Wind Project Permit, Section 5: Noise, October 30, 2008, Prepared by Resource Systems Engineering

Maine. Department of Environmental Protection, Department Order for Spruce Mountain Wind Project Permit, October, 2010

Maine. Department of Environmental Protection, Department Order for Oakfield Wind Project Permit, January, 2010

Maine. Land Use Regulation Commission, Chapter 4 Rules of Practice

Maine. Land Use Regulation Commission, Chapter 10 Noise Regulations

Maine. Department of Environmental Protection. Affidavit of Michael Nissenbaum M.D., related to Saddleback Mountain Wind project.

Massachusetts. Noise Pollution Policy Interpretation

Massachusetts**.** Commonwealth of Massachusetts Department of Environmental Protection, Noise Control Regulation 310 CMR 7.10

Massachusetts Clean Energy Center, New England Wind Energy Education Project, Bastasch, Mark, Ken Kalisky, Jim Cummings, and Bob Grace, "Understanding the Impacts of Wind Turbine Sound", webinar, July 13, 2010

Massachusetts Clean Energy Center, New England Wind Energy Education Project, Mott, Lawrence and Robert McCunney M.D., "Wind Turbine Sound and Health Effects", webinar, July 15, 2010

McCunney, Robert J. M.D., "Wind Turbines: Do they affect our health?," American Wind Energy Association position paper, PowerPoint presentation, November 20, 20009

McFadden, Jevon, "Wind Turbines: A Brief Health Overview", PowerPoint presentation to Wisconsin Wind Siting Council, May 17, 2010

McKenzie, Hayes, "The Measurement of Low Frequency Noise at Three U.K. Windfarms", report for U.K. Department of Trade and Industry, 2006

Minnesota. Department of Health, Environmental Division. Public Health Impacts of Wind Turbines Report, May 22, 2009.

Moorehouse, Andy, Malcolm Hayes, Sabine von Hunerbein, Ben Piper and Mags Adams, U.K. University of Salford, "Research into Aerodynamic Modulation of Wind Turbine Noise: Final Report, prepared for defra", July 2007

National Academy of Sciences," Environmental Impacts of Wind-Energy Projects", 2007, Page 157, http://books.nap.edu/openbook.php?record_id=11935&page=157

National Renewable Energy Lab, "Action Plan for Investigating Noise Issues at Fox Islands Wind Project", September 23, 2010

New Hampshire. State Energy Policy Commission Final Report. 2008 includes Appendix A.11 – Guidance for Evaluation of Individual Issues: Noise, Wind Energy Facility Siting Guidelines Working Group, Proposed Windpower Siting Guidelines, May 29, 2007

New Hampshire. Chapter site 200 Practice and Procedure Rules, June 16, 2008

New Hampshire. Energy Facility Siting in New Hampshire, The Energy Facility Siting Process in New Hampshire

Ohio. Bureau of Environmental Health, Health Assessment Section. Literature Search on the Potential Health Impacts Associated with Wind-to-Energy Turbine Operations. March, 2008.

Ontario. Chief Medical Officer, The Potential Health Impact of Wind Turbines. May 2010.

Ontario. Ministry of the Environment's, Wind Turbine Facilities Noise Issues, December, 2007

Oregon. Department of Environmental Quality, Oregon Administrative Rules Chapter 340, Division 35, Sound regulations

Oregon. Department of Environmental Quality, Oregon Administrative Rules Chapter 340, Division 35, Industrial and Commercial Noise Standards

Oregon. Energy Facility Siting Council

Oregon. Health Impact Assessment, www.oregon.gov/DHS/ph/hia/windenergy.shtml

Oregon. Press release on Listening Sessions, Oregon Health Authority, October 22, 2010

Pan Atlantic SMS Group, "Report to Maine Renewable Energy Association: Highlights of Survey Findings", May 2010

Pedersen, Eja, "Effects of Wind Turbine Noise on Humans", Third International Meeting on Wind Turbine Noise, June, 2009

Pedersen, Eja, and Kerstin Waye, "Perception and Annoyance due to Wind Turbine Noise – a Dose-Response Relationship", Department of Environmental Medicine, Goteborg University, September 2004

Phillips, Carl V, PhD. MPP, "An analysis of the Epidemiology and Related Evidence on the Health Effects of Wind Turbines on Local Residents", prepared at the request of Brown County Citizens for Responsible Wind Energy in connection with Public Service Commission of Wisconsin docket# 1-AC-231, Wind Siting Rules, July 3, 2010

Resource Systems Engineering, "Mars Hill Sound Level Study: Compilation Of Ambient & Quarterly Operations Sound Testing", October 15, 2008

Roberts, Mark M.D. and Jennifer Roberts, "Evaluation of the Scientific Literature on the Health Effects Associated with Wind Turbines and Low Frequency Sound", prepared for Wisconsin Public Service Commission Docket #6630-CE-302, October 20, 2009

Rogers, Anthony PhD., "Wind Turbine Noise, Infrasound and Noise Perception", Renewable Energy Research Laboratory, University of Massachusetts at Amherst, PowerPoint presentation, January 18, 2006

Rogers, Anthony, PhD., James Manwell, PhD., and Sally Wright, M.S. PE, "Wind Turbine Acoustic Noise, A White Paper", prepared for Renewable Energy Research Laboratory, Department of Mechanical and Industrial Engineering, University of Massachusetts, Amherst, June, 2002, amended in January, 2006

Rhode Island. Terrestrial Wind Turbine Siting Report, January 13, 2009

Shepard, Ian "Wake Induced Wind Turbine Noise", November 1, 2010

United Kingdom. University of Salford, Research into Aerodynamic Modulation of Wind Turbine Noise: Final Report, Prepared for Department of Environment, Food and Rural Affairs, July 2007

United Kingdom. The Assessment and Rating of Noise from Wind Farms: The working Group on Noise from Wind Turbines, Department of Trade and Industry, September, 1996

U.S. Environmental Protection Agency, "EPA Identifies Noise Levels Affecting Health and Welfare", EPA history

Van den Berg, Fritz, Edja Peterson, Jelte Bouma and Rouel Bakker, "Project WINDFARMperception Visual and acoustic impact of wind turbine farms on residents", University of Gothenburg, June 3, 2008

Wisconsin. Wind Siting Rules, August, 2010

Wisconsin. Public Service Commission of Wisconsin, Press Release, PSC Finalizes Wind Siting Rules, August 30, 2010

Wisconsin. Public Service Commission of Wisconsin, Modifications to final Wind Siting Rules, December, 2010

World Health Organization, "Night Noise Guidelines for Europe", 2009

World Health Organization, "Guidelines for Community Noise", 1999

Yardley, William "Turbines too loud? Here take $5,000" New York Times, July 31, 2010

"No Link Between Wind Turbines and Health: Report", (Australia's National Health and Medical Research Council, www.renewableenergyfocus.com, July 8, 2010

ATTACHMENTS FOR PART A

GOVERNOR'S OFFICE OF
ENERGY INDEPENDENCE AND SECURITY

KENNETH C. FLETCHER - DIRECTOR

Attachment #1

Greenhouse Gas Emissions Data for New England States

Rhode Island GHG Emissions

Emissions (MMTCO2E)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Energy	9.22	11.10	13.39	11.18	13.15	12.38	13.81	13.87	14.12	13.44	12.00	12.52	11.96	11.64	11.15	11.45	10.91
CO2 from Fossil Fuel Combustion	8.91	10.81	13.08	10.88	12.85	12.09	13.51	13.59	13.82	13.16	11.72	12.27	11.73	11.42	10.94	11.26	10.76
Stationary Combustion	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.02
Mobile Combustion	0.24	0.24	0.26	0.25	0.24	0.23	0.24	0.23	0.25	0.24	0.23	0.21	0.19	0.18	0.17	0.15	0.14
Coal Mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas and Oil Systems	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial Processes	0.08	0.08	0.08	0.09	0.12	0.19	0.21	1.08	1.06	0.96	1.07	1.04	1.09	0.98	1.16	1.03	1.00
Agriculture	0.04	0.04	0.05	0.06	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Enteric Fermentation	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Manure Management	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice Cultivation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agricultural Soil Management	0.03	0.03	0.04	0.04	0.03	0.02	0.02	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.04	0.03
Burning of Agricultural Crop Waste	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LULUCF	(1.76)	(1.62)	(1.59)	(1.44)	(1.35)	(1.25)	(1.15)	(1.13)	(0.75)	(0.20)	(0.20)	(0.21)	(0.22)	(0.16)	(0.13)	(0.14)	(0.15)
Waste	0.37	0.38	0.37	0.35	0.33	0.35	0.40	0.16	0.06	0.07	(0.17)	(0.04)	0.09	0.18	0.32	0.43	0.46
Municipal Solid Waste	0.27	0.29	0.28	0.26	0.24	0.25	0.30	0.06	(0.04)	(0.02)	(0.27)	(0.15)	(0.02)	0.07	0.22	0.32	0.36
Wastewater	0.09	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Gross Emissions	**9.71**	**11.60**	**13.90**	**11.69**	**13.65**	**12.95**	**14.46**	**15.15**	**15.28**	**14.53**	**12.95**	**13.57**	**13.18**	**12.85**	**12.68**	**12.96**	**12.43**
Sinks	**(1.76)**	**(1.62)**	**(1.59)**	**(1.44)**	**(1.35)**	**(1.25)**	**(1.15)**	**(1.13)**	**(0.75)**	**(0.20)**	**(0.20)**	**(0.21)**	**(0.22)**	**(0.16)**	**(0.13)**	**(0.14)**	**(0.15)**
Net Emissions	**7.94**	**9.99**	**12.31**	**10.25**	**12.29**	**11.70**	**13.31**	**14.02**	**14.54**	**14.33**	**12.74**	**13.36**	**12.96**	**12.69**	**12.55**	**12.83**	**12.29**

CO2 from Fossil Fuel Combustion

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Residential	2.34	2.35	2.78	2.66	2.71	2.50	2.67	2.62	2.39	2.33	2.51	2.58	2.49	2.77	2.80	2.74	2.23
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	1.37	1.40	1.69	1.58	1.75	1.55	1.57	1.62	1.49	1.43	1.48	1.60	1.51	1.67	1.73	1.67	1.29
Natural Gas	0.96	0.95	1.08	1.08	0.95	0.95	1.10	1.00	0.90	0.91	1.04	0.98	0.98	1.10	1.07	1.07	0.94
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Commercial	1.11	1.16	1.08	1.13	1.38	1.25	1.42	1.34	1.13	1.08	1.22	1.25	1.16	1.27	1.20	1.15	0.96
Coal	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00
Petroleum	0.66	0.70	0.58	0.62	0.71	0.59	0.69	0.66	0.50	0.43	0.50	0.55	0.52	0.64	0.58	0.53	0.40
Natural Gas	0.44	0.45	0.49	0.50	0.66	0.66	0.72	0.68	0.62	0.64	0.72	0.70	0.64	0.62	0.62	0.62	0.56
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Industrial	0.66	1.81	3.00	1.00	2.63	2.24	1.82	1.66	2.55	2.13	0.69	0.55	0.53	0.57	0.61	0.62	0.62
Coal	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum	0.43	0.37	0.47	0.50	0.44	0.37	0.35	0.35	0.31	0.30	0.25	0.23	0.29	0.33	0.31	0.30	0.27
Natural Gas	0.23	1.43	2.54	0.51	2.19	1.87	1.47	1.31	2.24	1.83	0.43	0.32	0.24	0.24	0.29	0.32	0.35
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transportation	4.13	4.14	4.06	4.09	4.01	4.12	4.16	4.62	4.47	4.65	4.64	4.68	4.63	4.52	4.38	4.37	4.61
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum	4.12	4.13	4.04	4.08	3.99	4.09	4.12	4.57	4.45	4.64	4.62	4.66	4.61	4.50	4.36	4.32	4.61
Natural Gas	0.01	0.01	0.02	0.01	0.02	0.03	0.04	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.05	0.00
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electric Utilities	0.67	1.36	2.17	1.99	2.12	1.98	3.44	3.36	3.28	2.97	2.66	3.21	2.93	2.29	1.96	2.39	2.33
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum	0.18	0.09	0.09	0.04	0.05	0.04	0.06	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Natural Gas	0.50	1.27	2.08	1.96	2.07	1.94	3.38	3.33	3.26	2.95	2.65	3.20	2.91	2.28	1.95	2.38	2.32
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
International Bunker Fuels	-	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum	-	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	8.91	10.81	13.08	10.88	12.85	12.09	13.51	13.59	13.82	13.16	11.72	12.27	11.73	11.42	10.94	11.26	10.76
Coal	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Petroleum	6.76	6.69	6.86	6.82	6.95	6.64	6.80	7.23	6.77	6.81	6.86	7.05	6.93	7.15	6.99	6.83	6.58
Natural Gas	2.14	4.11	6.21	4.05	5.89	5.45	6.71	6.36	7.05	6.35	4.85	5.21	4.79	4.26	3.94	4.42	4.17
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

New York GHG Emissions

Emissions (MMTCO2E)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Energy	214.56	206.96	206.08	201.45	199.20	204.35	209.16	214.10	212.52	214.65	220.37	212.43	204.45	216.59	219.32	214.10	197.50
CO2 from Fossil Fuel Combustion	210.15	202.44	201.38	196.52	194.32	199.47	204.14	208.81	207.38	209.73	215.45	207.96	200.36	212.60	215.47	210.46	194.74
Stationary Combustion	0.94	0.92	0.94	1.03	0.97	0.95	1.01	1.29	1.17	1.22	1.31	1.03	0.99	1.06	1.08	1.08	0.41
Mobile Combustion	3.45	3.60	3.75	3.89	3.91	3.93	4.01	3.99	3.97	3.70	3.61	3.45	3.10	2.93	2.76	2.56	2.36
Coal Mining	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Natural Gas and Oil Systems	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial Processes	2.59	2.53	2.64	2.88	3.42	4.53	5.17	6.68	6.96	7.37	7.80	8.07	8.60	8.75	9.49	9.66	10.04
Agriculture	5.80	5.66	5.84	5.69	5.82	5.46	5.30	5.29	5.58	5.47	5.51	5.37	5.58	5.66	5.76	5.76	5.62
Enteric Fermentation	2.71	2.71	2.75	2.65	2.61	2.57	2.47	2.49	2.51	2.52	2.55	2.45	2.50	2.57	2.50	2.54	2.56
Manure Management	0.68	0.70	0.67	0.68	0.68	0.70	0.68	0.68	0.73	0.75	0.74	0.75	0.79	0.77	0.75	0.85	0.87
Rice Cultivation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agricultural Soil Management	2.41	2.25	2.42	2.36	2.53	2.19	2.15	2.12	2.34	2.19	2.21	2.16	2.29	2.31	2.50	2.36	2.19
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LULUCF	(38.31)	(35.87)	(35.99)	(37.50)	(35.94)	(34.03)	(32.31)	(31.98)	(31.73)	(31.11)	(31.01)	(31.09)	(31.04)	(29.89)	(29.61)	(29.81)	(29.96)
Waste	13.67	13.87	14.45	14.64	14.82	14.20	14.48	14.11	13.96	13.37	13.55	13.21	13.90	14.70	15.34	15.51	15.58
Municipal Solid Waste	11.97	12.16	12.72	12.91	13.08	12.47	12.74	12.38	12.22	11.62	11.72	11.36	12.05	12.85	13.48	13.64	13.71
Wastewater	1.70	1.71	1.73	1.73	1.74	1.73	1.74	1.73	1.74	1.75	1.83	1.85	1.84	1.85	1.86	1.87	1.87
Gross Emissions	**236.63**	**229.01**	**229.00**	**224.66**	**223.26**	**228.54**	**234.11**	**240.18**	**239.02**	**240.86**	**247.22**	**239.09**	**232.53**	**245.70**	**249.91**	**245.03**	**228.75**
Sinks	**(38.31)**	**(35.87)**	**(35.99)**	**(37.50)**	**(35.94)**	**(34.03)**	**(32.31)**	**(31.98)**	**(31.73)**	**(31.11)**	**(31.01)**	**(31.09)**	**(31.04)**	**(29.89)**	**(29.61)**	**(29.81)**	**(29.96)**
Net Emissions	**198.31**	**193.15**	**193.01**	**187.16**	**187.32**	**194.51**	**201.80**	**208.20**	**207.29**	**209.74**	**216.21**	**208.00**	**201.49**	**215.81**	**220.29**	**215.21**	**198.78**

CO2 from Fossil Fuel Combustion

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Residential	33.65	32.92	36.29	35.72	35.32	34.29	36.63	34.73	31.66	34.36	39.30	38.23	35.16	39.03	38.06	39.11	32.61
Coal	0.13	0.12	0.12	0.10	0.07	0.07	0.08	0.07	0.04	0.05	0.03	0.03	0.01	0.03	0.04	0.03	0.03
Petroleum	15.07	14.34	15.51	14.65	14.24	13.73	14.59	14.21	13.09	14.09	17.37	17.59	15.92	16.31	16.79	16.94	13.19
Natural Gas	18.44	18.45	20.66	20.96	21.01	20.50	21.95	20.45	18.53	20.21	21.90	20.61	19.23	22.69	21.23	22.13	19.40
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Commercial	27.06	26.69	27.71	28.43	27.87	27.06	27.90	29.69	27.70	30.18	32.06	30.63	30.38	33.08	34.51	28.65	25.46
Coal	0.53	0.56	0.55	0.46	0.38	0.47	0.60	0.54	0.32	0.38	0.22	0.24	0.09	0.18	0.34	0.35	0.30
Petroleum	15.90	15.26	15.31	15.93	15.32	13.95	13.52	11.68	9.08	10.16	11.82	11.37	11.43	14.11	14.76	13.28	11.01
Natural Gas	10.64	10.87	11.85	12.04	12.17	12.64	13.78	17.47	18.30	19.64	20.02	19.02	18.85	18.80	19.41	15.02	14.15
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Industrial	21.42	20.92	22.26	22.25	22.28	24.00	26.72	26.12	25.38	21.29	20.73	16.76	15.24	15.16	15.02	15.00	15.30
Coal	7.74	7.70	6.68	7.14	6.71	6.45	6.46	6.82	6.72	6.39	6.59	5.70	4.09	3.80	3.56	3.65	3.30
Petroleum	8.22	6.81	7.61	7.48	6.95	6.07	8.78	8.32	9.48	9.49	8.98	6.55	6.44	6.86	7.31	7.06	7.87
Natural Gas	5.46	6.40	7.96	7.62	8.62	11.47	11.48	10.99	9.18	5.42	5.16	4.52	4.72	4.50	4.14	4.30	4.13
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transportation	64.01	62.41	60.81	62.18	61.17	62.74	65.88	65.79	66.20	66.79	67.20	66.99	68.54	72.97	75.04	72.13	74.83
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum	63.76	62.13	60.49	61.84	60.83	62.28	65.44	65.38	65.76	66.32	66.75	66.66	68.08	72.51	74.57	71.44	72.65
Natural Gas	0.26	0.27	0.33	0.34	0.34	0.46	0.44	0.41	0.43	0.47	0.45	0.33	0.47	0.46	0.47	0.70	2.18
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electric Utilities	64.01	59.51	54.31	47.95	47.68	51.38	47.01	52.47	56.44	57.10	56.16	55.35	51.04	52.36	52.85	55.58	46.54
Coal	24.37	24.61	25.98	22.83	22.15	21.27	21.73	23.05	23.82	22.36	23.56	22.29	21.67	22.39	21.60	19.70	19.96
Petroleum	27.09	22.41	14.46	11.99	9.78	6.76	7.95	7.01	12.15	11.26	12.45	13.75	9.62	15.81	17.25	19.41	5.62
Natural Gas	12.55	12.49	13.87	13.12	15.74	23.34	17.33	22.42	20.48	23.48	20.15	19.30	19.75	14.16	14.00	16.46	20.97
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
International Bunker Fuels	-	0.00	0.03	0.01	0.01	0.01	0.02	0.02	0.03	0.02	0.01	-	-	0.00	-	0.01	-
Petroleum	-	0.00	0.03	0.01	0.01	0.01	0.02	0.02	0.03	0.02	0.01	-	-	0.00	-	0.01	-
TOTAL	210.15	202.44	201.38	196.52	194.32	199.47	204.14	208.81	207.38	209.73	215.45	207.96	200.36	212.60	215.47	210.46	194.74
Coal	32.77	32.99	33.33	30.54	29.31	28.26	28.87	30.47	30.89	29.19	30.40	28.26	25.86	26.39	25.54	23.73	23.58
Petroleum	130.04	120.95	113.38	111.89	107.13	102.79	110.28	106.61	109.56	111.33	117.37	115.92	111.49	125.60	130.68	128.13	110.33
Natural Gas	47.35	48.49	54.67	54.09	57.88	68.42	64.98	71.73	66.92	69.21	67.68	63.78	63.02	60.61	59.25	58.61	60.82
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

New Jersey GHG Emissions

Emissions (MMTCO2E)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Energy	117.82	118.54	125.40	122.28	132.07	131.30	128.93	130.69	125.76	128.67	128.92	126.70	126.58	128.02	131.12	136.07	127.33
CO2 from Fossil Fuel Combustion	115.37	116.01	122.79	119.66	129.42	128.65	126.31	128.14	123.26	126.31	126.56	124.44	124.51	126.09	129.25	134.23	125.83
Stationary Combustion	0.32	0.33	0.35	0.32	0.34	0.33	0.34	0.30	0.27	0.28	0.29	0.28	0.27	0.29	0.29	0.29	0.16
Mobile Combustion	2.13	2.20	2.26	2.30	2.32	2.32	2.28	2.26	2.23	2.07	2.06	1.98	1.79	1.64	1.58	1.54	1.34
Coal Mining	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Natural Gas and Oil Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Industrial Processes	0.73	0.71	0.73	0.83	1.00	1.45	1.73	2.84	2.94	3.04	3.30	3.45	3.68	3.73	4.08	4.10	4.15
Agriculture	0.62	0.62	0.61	0.65	0.62	0.54	0.58	0.57	0.59	0.61	0.54	0.54	0.51	0.52	0.56	0.55	0.47
Enteric Fermentation	0.14	0.14	0.14	0.14	0.12	0.12	0.12	0.12	0.11	0.11	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Manure Management	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02
Rice Cultivation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agricultural Soil Management	0.45	0.44	0.44	0.47	0.46	0.38	0.43	0.42	0.44	0.47	0.42	0.42	0.40	0.40	0.43	0.43	0.36
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LULUCF	(18.56)	(17.51)	(17.41)	(16.24)	(15.61)	(14.82)	(14.11)	(14.01)	(14.30)	(15.45)	(15.40)	(15.47)	(15.60)	(15.14)	(14.92)	(15.01)	(15.11)
Waste	6.10	6.02	5.66	5.71	5.58	5.54	5.14	4.03	3.19	3.20	2.98	3.26	3.17	3.47	3.90	3.89	3.75
Municipal Solid Waste	5.37	5.28	4.91	4.96	4.82	4.78	4.37	3.26	2.42	2.41	2.17	2.43	2.34	2.64	3.07	3.05	2.91
Wastewater	0.73	0.74	0.75	0.75	0.76	0.76	0.77	0.77	0.78	0.78	0.81	0.83	0.83	0.83	0.84	0.84	0.85
Gross Emissions	**125.27**	**125.90**	**132.40**	**129.47**	**139.27**	**138.83**	**136.38**	**138.13**	**132.47**	**135.51**	**135.74**	**133.96**	**133.93**	**135.73**	**139.65**	**144.60**	**135.71**
Sinks	**(18.56)**	**(17.51)**	**(17.41)**	**(16.24)**	**(15.61)**	**(14.82)**	**(14.11)**	**(14.01)**	**(14.30)**	**(15.45)**	**(15.40)**	**(15.47)**	**(15.60)**	**(15.14)**	**(14.92)**	**(15.01)**	**(15.11)**
Net Emissions	**106.71**	**108.39**	**115.00**	**113.23**	**123.66**	**124.01**	**122.27**	**124.12**	**118.18**	**120.06**	**120.34**	**118.49**	**118.33**	**120.59**	**124.74**	**129.59**	**120.59**

CO2 from Fossil Fuel Combustion

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Residential	15.47	15.44	16.75	16.42	18.25	16.24	17.92	17.18	15.23	16.24	17.00	16.49	15.88	18.43	17.48	16.90	14.17
Coal	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	6.14	5.84	5.96	5.65	6.26	5.57	5.68	5.27	4.41	4.70	4.93	4.65	4.27	4.92	4.67	4.14	3.33
Natural Gas	9.32	9.60	10.79	10.77	11.98	10.66	12.24	11.90	10.81	11.54	12.08	11.83	11.60	13.50	12.82	12.76	10.84
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Commercial	10.92	11.02	11.41	10.79	11.04	10.05	11.22	11.51	10.16	11.70	10.97	9.50	9.53	10.58	10.84	11.24	9.52
Coal	0.03	0.02	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Petroleum	4.61	4.40	4.26	3.67	3.72	2.41	2.93	2.24	2.09	2.66	2.25	2.25	1.44	1.73	1.52	1.86	1.13
Natural Gas	6.28	6.59	7.12	7.10	7.29	7.62	8.27	9.26	8.06	9.03	8.71	7.23	8.08	8.84	9.30	9.38	8.38
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Industrial	19.61	19.51	23.71	23.76	24.23	24.10	22.40	22.63	21.35	21.20	14.81	16.84	16.24	17.02	17.45	16.91	16.45
Coal	0.66	0.56	0.51	0.53	0.17	0.03	0.02	0.03	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.01	0.01
Petroleum	14.14	13.59	13.87	13.02	13.77	12.85	11.87	12.26	10.68	10.62	10.08	12.23	11.89	12.83	13.31	12.90	12.91
Natural Gas	4.81	5.36	9.33	10.21	10.29	11.21	10.51	10.35	10.65	10.57	4.71	4.59	4.33	4.18	4.13	4.00	3.53
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transportation	57.16	57.98	58.19	55.29	60.45	61.31	59.00	59.72	60.63	60.56	64.92	63.01	63.85	62.10	64.61	70.10	67.61
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum	57.01	57.82	57.99	55.13	60.31	61.17	58.83	59.53	60.47	60.32	64.74	62.78	63.75	61.99	64.51	70.02	62.28
Natural Gas	0.14	0.16	0.19	0.16	0.14	0.14	0.18	0.19	0.16	0.24	0.17	0.22	0.10	0.11	0.10	0.08	5.33
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electric Utilities	12.22	12.06	12.73	13.39	15.44	16.96	15.76	17.10	15.89	16.61	18.87	18.61	19.02	17.96	18.87	19.09	18.08
Coal	6.89	5.22	5.33	5.38	5.90	7.44	8.09	9.32	7.91	8.23	10.62	10.39	9.71	9.89	10.43	11.61	10.76
Petroleum	1.70	1.61	1.03	1.10	1.64	1.21	0.64	0.38	0.55	0.65	0.85	1.20	0.54	0.93	0.71	0.61	0.16
Natural Gas	3.63	5.23	6.37	6.92	7.91	8.32	7.03	7.39	7.43	7.73	7.40	7.02	8.77	7.14	7.72	6.86	7.17
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
International Bunker Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	115.37	116.01	122.79	119.66	129.42	128.65	126.31	128.14	123.26	126.31	126.56	124.44	124.51	126.09	129.25	134.23	125.83
Coal	7.58	5.81	5.88	5.92	6.10	7.48	8.12	9.36	7.95	8.26	10.65	10.41	9.73	9.92	10.46	11.63	10.77
Petroleum	83.61	83.26	83.11	78.56	85.70	83.21	79.95	79.68	78.20	78.94	82.85	83.12	81.90	82.40	84.72	89.53	79.81
Natural Gas	24.18	26.94	33.80	35.17	37.62	37.96	38.23	39.09	37.11	39.11	33.07	30.91	32.88	33.77	34.07	33.08	35.25
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Connecticut GHG emissions

Emissions (MMTCO2E)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Energy	42.03	41.34	41.63	39.74	39.05	38.28	41.47	44.50	42.12	43.31	44.55	42.67	41.04	43.13	45.17	43.94	42.19	-
CO2 from Fossil Fuel Combustion	40.98	40.25	40.51	38.59	37.91	37.12	40.31	43.36	41.01	42.27	43.50	41.68	40.16	42.28	44.36	43.18	41.59	-
Stationary Combustion	0.20	0.20	0.21	0.21	0.20	0.21	0.22	0.21	0.19	0.19	0.21	0.19	0.17	0.19	0.19	0.19	0.08	-
Mobile Combustion	0.85	0.89	0.90	0.93	0.93	0.95	0.94	0.93	0.92	0.86	0.85	0.81	0.71	0.66	0.62	0.57	0.52	-
Coal Mining	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Natural Gas and Oil Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Industrial Processes	0.31	0.30	0.31	0.34	0.43	0.62	0.74	1.69	1.68	1.64	1.80	1.83	1.93	1.87	2.12	2.03	2.01	-
Agriculture	0.34	0.33	0.38	0.38	0.39	0.38	0.32	0.31	0.33	0.34	0.32	0.33	0.35	0.33	0.32	0.43	0.29	-
Enteric Fermentation	0.14	0.13	0.13	0.13	0.13	0.13	0.12	0.12	0.12	0.12	0.12	0.11	0.11	0.10	0.10	0.10	0.09	-
Manure Management	0.05	0.05	0.07	0.07	0.07	0.07	0.05	0.04	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.10	0.04	-
Rice Cultivation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agricultural Soil Management	0.16	0.14	0.18	0.18	0.19	0.18	0.15	0.15	0.16	0.17	0.16	0.17	0.20	0.19	0.18	0.23	0.15	-
Burning of Agricultural Crop Waste	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LULUCF	(8.01)	(7.55)	(7.47)	(6.53)	(6.24)	(5.91)	(5.61)	(5.54)	(0.46)	2.81	2.83	2.80	2.77	2.94	3.04	3.00	2.96	4.49
Waste	1.55	1.72	1.60	1.49	1.71	1.70	1.66	1.31	1.59	1.57	1.62	1.54	1.33	1.65	1.94	2.09	2.06	0.34
Municipal Solid Waste	1.24	1.40	1.29	1.18	1.40	1.39	1.35	1.00	1.28	1.25	1.29	1.20	1.00	1.31	1.60	1.75	1.72	-
Wastewater	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.32	0.33	0.33	0.33	0.33	0.34	0.34	0.34	0.34
Gross Emissions	**44.23**	**43.68**	**43.92**	**41.96**	**41.58**	**40.99**	**44.18**	**47.80**	**45.72**	**49.67**	**51.13**	**49.16**	**47.43**	**49.93**	**52.58**	**51.48**	**49.51**	**4.83**
Sinks	**(8.01)**	**(7.55)**	**(7.47)**	**(6.53)**	**(6.24)**	**(5.91)**	**(5.61)**	**(5.54)**	**(0.46)**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Net Emissions	**36.22**	**36.13**	**36.45**	**35.43**	**35.33**	**35.08**	**38.57**	**42.26**	**45.26**	**49.67**	**51.13**	**49.16**	**47.43**	**49.93**	**52.58**	**51.48**	**49.51**	**4.83**

CO2 from Fossil Fuel Combustion

MMTCO2E	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Residential	8.11	7.86	9.33	8.90	8.51	7.82	8.30	8.06	7.03	7.92	8.66	8.40	8.16	9.48	10.12	9.28	8.05	-
Coal	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Petroleum	6.06	5.82	7.01	6.60	6.23	5.58	5.91	5.85	5.11	5.84	6.40	6.17	5.95	7.04	7.78	6.84	5.89	-
Natural Gas	2.05	2.03	2.31	2.30	2.27	2.23	2.39	2.21	1.92	2.08	2.26	2.22	2.21	2.43	2.33	2.43	2.16	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Commercial	3.76	3.58	4.22	3.76	4.10	3.76	4.04	4.20	3.92	4.19	4.44	4.20	4.04	4.72	3.75	3.66	3.28	-
Coal	0.02	0.03	0.04	0.03	0.03	0.05	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-
Petroleum	2.13	2.08	2.55	2.02	1.94	1.65	1.86	1.86	1.60	1.60	1.78	1.79	1.80	2.64	1.87	1.70	1.46	-
Natural Gas	1.61	1.47	1.63	1.71	2.14	2.07	2.17	2.32	2.30	2.58	2.64	2.41	2.22	2.07	1.87	1.95	1.81	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Industrial	3.17	3.43	3.68	3.68	3.28	3.01	3.55	3.46	3.32	3.34	3.41	2.62	2.56	2.96	2.72	2.74	2.66	-
Coal	0.00	0.01	0.03	0.07	0.07	-	-	(0.00)	-	-	-	-	-	-	-	0.00	-	-
Petroleum	1.80	1.67	1.70	1.65	1.57	1.30	1.82	1.62	1.60	1.65	1.71	1.28	1.00	1.74	1.67	1.66	1.50	-
Natural Gas	1.37	1.75	1.95	1.97	1.64	1.72	1.73	1.84	1.72	1.69	1.70	1.35	1.55	1.22	1.05	1.08	1.16	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transportation	14.67	14.55	14.61	14.75	14.69	14.38	15.16	15.20	15.41	16.68	16.17	16.89	16.81	17.30	19.18	17.60	18.20	-
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum	14.64	14.52	14.58	14.73	14.65	14.32	15.08	15.05	15.36	16.52	16.00	16.72	16.67	17.11	18.99	17.42	18.20	-
Natural Gas	0.03	0.03	0.03	0.03	0.04	0.07	0.08	0.14	0.05	0.17	0.17	0.17	0.15	0.19	0.19	0.19	0.00	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electric Power	11.26	10.83	8.68	7.50	7.33	8.14	9.26	12.45	11.32	10.13	10.81	9.56	8.59	7.82	8.60	9.89	9.40	-
Coal	3.55	3.55	3.57	3.37	3.49	3.73	3.81	4.17	2.98	1.40	3.36	3.70	3.17	3.88	4.08	3.89	4.24	-
Petroleum	7.02	6.45	4.38	3.49	2.84	2.84	4.48	6.95	7.22	7.03	5.61	4.13	1.90	1.67	1.35	2.58	1.10	-
Natural Gas	0.69	0.83	0.74	0.63	1.00	1.57	0.97	1.32	1.11	1.70	1.85	1.73	3.52	2.27	3.17	3.43	4.07	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
International Bunker Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	40.98	40.25	40.51	38.59	37.91	37.12	40.31	43.36	41.01	42.27	43.50	41.68	40.16	42.28	44.36	43.18	41.59	-
Coal	3.58	3.59	3.64	3.47	3.59	3.79	3.82	4.19	3.00	1.42	3.37	3.71	3.18	3.89	4.09	3.90	4.25	-
Petroleum	31.65	30.56	30.22	28.48	27.23	25.68	29.15	31.34	30.90	32.63	31.50	30.09	27.33	30.21	31.66	30.20	28.14	-
Natural Gas	5.75	6.10	6.65	6.64	7.09	7.65	7.34	7.84	7.11	8.22	8.63	7.87	9.65	8.18	8.62	9.08	9.20	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Vermont GHG Emissions

Emissions (MMTCO2E)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Energy	5.68	5.89	6.35	6.43	6.27	6.22	6.50	6.70	6.46	6.70	6.93	6.84	6.56	6.72	7.17	6.95	6.88	-
CO2 from Fossil Fuel Combustion	5.46	5.67	6.11	6.19	6.02	5.98	6.26	6.46	6.22	6.48	6.71	6.56	6.31	6.51	6.98	6.78	6.74	-
Stationary Combustion	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.04	0.04	0.03	0.04	0.04	0.04	0.04	0.01	-
Mobile Combustion	0.18	0.19	0.20	0.20	0.21	0.20	0.21	0.20	0.20	0.18	0.18	0.25	0.22	0.17	0.15	0.14	0.13	-
Coal Mining	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Natural Gas and Oil Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Industrial Processes	0.12	0.12	0.12	0.14	0.18	0.25	0.29	0.33	0.32	0.31	0.27	0.24	0.23	0.24	0.27	0.28	0.28	-
Agriculture	1.04	0.98	1.00	1.00	1.00	0.97	0.99	0.96	1.04	1.01	1.01	1.00	1.00	0.99	1.01	0.98	0.97	-
Enteric Fermentation	0.56	0.54	0.54	0.55	0.53	0.53	0.52	0.52	0.54	0.54	0.53	0.53	0.52	0.52	0.51	0.50	0.50	-
Manure Management	0.13	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.15	0.16	0.15	0.16	0.16	0.16	0.15	0.16	0.16	-
Rice Cultivation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agricultural Soil Management	0.36	0.32	0.34	0.32	0.34	0.31	0.34	0.31	0.36	0.32	0.33	0.31	0.32	0.30	0.35	0.32	0.31	-
Burning of Agricultural Crop Waste	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LULUCF	(9.43)	(9.44)	(9.44)	(9.48)	(9.48)	(9.48)	(9.48)	(0.61)	3.06	3.06	3.06	3.06	3.05	3.05	3.05	3.05	3.05	4.28
Waste	0.07	0.07	0.07	0.09	0.11	0.14	0.21	0.10	0.15	0.08	0.11	0.12	0.13	0.14	0.15	0.05	0.06	0.06
Municipal Solid Waste	0.02	0.02	0.02	0.04	0.05	0.08	0.15	0.04	0.09	0.03	0.05	0.06	0.07	0.08	0.09	(0.01)	(0.00)	-
Wastewater	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Gross Emissions	**6.91**	**7.06**	**7.54**	**7.66**	**7.55**	**7.58**	**7.99**	**8.10**	**7.98**	**8.10**	**8.32**	**8.19**	**7.92**	**8.08**	**8.60**	**8.26**	**8.19**	**0.06**
Sinks	**(9.43)**	**(9.44)**	**(9.44)**	**(9.48)**	**(9.48)**	**(9.48)**	**(9.48)**	**(0.61)**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Net Emissions	**(2.52)**	**(2.38)**	**(1.90)**	**(1.82)**	**(1.93)**	**(1.90)**	**(1.49)**	**7.48**	**7.98**	**8.10**	**8.32**	**8.19**	**7.92**	**8.08**	**8.60**	**8.26**	**8.19**	**0.06**

CO2 from Fossil Fuel Combustion

MMTCO2E	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Residential	1.42	1.49	1.63	1.58	1.51	1.46	1.54	1.50	1.44	1.41	1.63	1.63	1.53	1.59	1.83	1.66	1.57	-
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Petroleum	1.31	1.38	1.50	1.45	1.38	1.34	1.41	1.36	1.31	1.28	1.48	1.49	1.39	1.43	1.67	1.50	1.42	-
Natural Gas	0.11	0.12	0.13	0.13	0.13	0.12	0.14	0.14	0.13	0.14	0.15	0.15	0.15	0.17	0.17	0.16	0.15	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Commercial	0.53	0.59	0.67	0.63	0.62	0.53	0.59	0.65	0.69	0.64	0.70	0.70	0.64	0.70	0.74	0.66	0.62	-
Coal	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Petroleum	0.41	0.47	0.53	0.49	0.47	0.39	0.44	0.48	0.52	0.51	0.56	0.56	0.51	0.55	0.59	0.52	0.49	-
Natural Gas	0.11	0.11	0.12	0.13	0.14	0.14	0.15	0.16	0.16	0.12	0.14	0.13	0.13	0.15	0.14	0.14	0.13	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Industrial	0.46	0.48	0.55	0.55	0.43	0.39	0.42	0.67	0.46	0.63	0.56	0.48	0.47	0.51	0.58	0.59	0.68	-
Coal	0.00	0.02	0.03	-	-	-	-	0.25	-	0.18	-	-	-	-	-	-	-	-
Petroleum	0.36	0.38	0.41	0.45	0.33	0.28	0.31	0.30	0.35	0.30	0.36	0.34	0.31	0.38	0.44	0.45	0.54	-
Natural Gas	0.10	0.09	0.10	0.11	0.10	0.11	0.10	0.12	0.11	0.15	0.21	0.14	0.16	0.13	0.14	0.14	0.15	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transportation	3.00	3.03	3.22	3.41	3.44	3.56	3.70	3.63	3.58	3.75	3.70	3.70	3.65	3.68	3.81	3.86	3.87	-
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum	3.00	3.03	3.21	3.40	3.44	3.56	3.69	3.62	3.58	3.75	3.69	3.70	3.64	3.68	3.81	3.86	3.87	-
Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electric Power	0.04	0.06	0.05	0.02	0.02	0.02	0.01	0.02	0.06	0.04	0.12	0.04	0.02	0.03	0.02	0.01	0.01	-
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum	0.00	0.01	0.00	0.01	0.01	0.02	0.01	0.01	0.05	0.03	0.07	0.04	0.01	0.02	0.02	0.01	0.00	-
Natural Gas	0.04	0.06	0.04	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.05	0.01	0.00	0.00	0.00	0.00	0.00	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
International Bunker Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	5.46	5.67	6.11	6.19	6.02	5.98	6.26	6.46	6.22	6.48	6.71	6.56	6.31	6.51	6.98	6.78	6.74	-
Coal	0.02	0.03	0.05	0.01	0.01	0.01	0.00	0.26	0.01	0.19	0.00	0.01	0.00	0.00	0.00	0.00	0.00	-
Petroleum	5.09	5.27	5.66	5.79	5.62	5.59	5.86	5.76	5.80	5.86	6.15	6.13	5.86	6.06	6.52	6.34	6.31	-
Natural Gas	0.35	0.37	0.40	0.38	0.38	0.38	0.39	0.44	0.41	0.43	0.55	0.42	0.44	0.44	0.46	0.44	0.43	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

New Hampshire GHG Emissions

Emissions (MMTCO2E)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Energy	15.10	14.77	14.88	15.41	15.48	15.54	16.15	17.44	17.43	17.57	18.16	17.20	17.88	20.91	22.15	21.50	20.06
CO2 from Fossil Fuel Combustion	14.68	14.34	14.44	14.95	15.02	15.08	15.68	16.98	16.97	17.13	17.73	16.79	17.51	20.53	21.79	21.15	19.79
Stationary Combustion	0.10	0.10	0.11	0.11	0.10	0.10	0.11	0.10	0.10	0.10	0.10	0.09	0.08	0.09	0.11	0.11	0.05
Mobile Combustion	0.31	0.32	0.33	0.35	0.35	0.35	0.36	0.36	0.36	0.34	0.33	0.32	0.29	0.28	0.26	0.24	0.22
Coal Mining	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Natural Gas and Oil Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Industrial Processes	0.11	0.11	0.11	0.12	0.16	0.23	0.27	0.32	0.33	0.36	0.39	0.41	0.44	0.47	0.50	0.52	0.54
Agriculture	0.19	0.18	0.19	0.19	0.19	0.19	0.18	0.18	0.18	0.18	0.19	0.18	0.19	0.18	0.19	0.20	0.19
Enteric Fermentation	0.08	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.08	0.08
Manure Management	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Rice Cultivation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agricultural Soil Management	0.09	0.08	0.08	0.08	0.09	0.08	0.09	0.08	0.09	0.08	0.09	0.09	0.09	0.09	0.10	0.10	0.09
Burning of Agricultural Crop Waste	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LULUCF	(3.46)	(3.47)	(3.49)	(4.49)	(4.51)	(4.53)	(4.54)	(7.17)	(7.47)	(7.49)	(7.50)	(7.52)	(7.54)	(7.56)	(7.57)	(7.59)	(7.61)
Waste	0.44	0.47	0.51	0.53	0.54	0.48	0.47	0.29	0.22	0.22	0.11	0.03	0.00	0.09	0.09	(0.03)	0.00
Municipal Solid Waste	0.33	0.37	0.40	0.42	0.43	0.37	0.36	0.18	0.11	0.11	(0.01)	(0.09)	(0.12)	(0.03)	(0.03)	(0.16)	(0.13)
Wastewater	0.10	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13
Gross Emissions	**15.84**	**15.53**	**15.69**	**16.24**	**16.37**	**16.44**	**17.07**	**18.23**	**18.16**	**18.34**	**18.84**	**17.82**	**18.51**	**21.65**	**22.94**	**22.19**	**20.79**
Sinks	**(3.46)**	**(3.47)**	**(3.49)**	**(4.49)**	**(4.51)**	**(4.53)**	**(4.54)**	**(7.17)**	**(7.47)**	**(7.49)**	**(7.50)**	**(7.52)**	**(7.54)**	**(7.56)**	**(7.57)**	**(7.59)**	**(7.61)**
Net Emissions	**12.38**	**12.05**	**12.20**	**11.75**	**11.86**	**11.91**	**12.53**	**11.05**	**10.69**	**10.85**	**11.34**	**10.30**	**10.97**	**14.09**	**15.36**	**14.60**	**13.19**

CO2 from Fossil Fuel Combustion

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Residential	2.47	2.46	2.57	2.56	2.63	2.76	2.94	2.91	2.84	2.87	2.93	2.86	2.68	3.24	3.40	3.17	2.82
Coal	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	2.14	2.15	2.22	2.21	2.27	2.41	2.56	2.53	2.50	2.51	2.52	2.47	2.28	2.84	3.00	2.75	2.45
Natural Gas	0.32	0.30	0.34	0.35	0.35	0.35	0.38	0.37	0.34	0.35	0.41	0.38	0.39	0.40	0.40	0.42	0.36
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Commercial	1.32	1.29	1.14	1.12	1.27	1.15	1.28	1.31	1.14	1.16	1.44	1.31	1.31	1.52	1.81	1.93	1.30
Coal	0.02	0.05	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01
Petroleum	1.02	0.97	0.80	0.77	0.91	0.79	0.88	0.89	0.76	0.77	0.97	0.88	0.81	1.03	1.30	1.39	0.83
Natural Gas	0.27	0.27	0.31	0.33	0.34	0.35	0.38	0.40	0.36	0.39	0.47	0.41	0.49	0.49	0.51	0.53	0.46
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Industrial	0.83	0.87	1.18	1.40	1.18	1.09	1.45	1.45	1.43	1.39	1.62	1.23	1.12	1.06	1.10	0.92	1.52
Coal	0.07	0.12	0.10	0.18	-	0.00	-	-	-	-	-	-	-	-	-	-	-
Petroleum	0.59	0.56	0.87	1.02	0.95	0.85	1.19	1.14	1.12	1.09	1.16	0.75	0.67	0.67	0.69	0.56	1.20
Natural Gas	0.17	0.18	0.20	0.20	0.23	0.24	0.26	0.31	0.31	0.31	0.46	0.47	0.44	0.39	0.41	0.36	0.32
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transportation	5.21	5.31	5.27	5.39	5.53	5.76	5.91	6.23	6.84	7.10	7.24	7.25	8.10	7.54	7.77	7.43	7.42
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum	5.21	5.31	5.26	5.38	5.48	5.75	5.90	6.21	6.83	7.10	7.24	7.25	8.10	7.54	7.77	7.43	7.42
Natural Gas	0.00	0.00	0.00	0.02	0.05	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electric Utilities	4.85	4.42	4.28	4.46	4.41	4.32	4.11	5.09	4.73	4.61	4.49	4.14	4.30	7.17	7.71	7.70	6.73
Coal	2.86	3.08	3.10	3.30	3.12	3.31	3.36	4.15	3.55	3.27	4.06	3.70	3.67	3.84	4.01	4.07	4.13
Petroleum	1.99	1.34	1.15	1.15	1.22	0.90	0.75	0.91	1.17	1.32	0.39	0.41	0.57	1.74	1.61	1.08	0.32
Natural Gas	-	-	0.03	0.01	0.07	0.12	0.00	0.03	0.01	0.03	0.04	0.03	0.06	1.59	2.09	2.54	2.28
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
International Bunker Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	14.68	14.34	14.44	14.95	15.02	15.08	15.68	16.98	16.97	17.13	17.73	16.79	17.51	20.53	21.79	21.15	19.79
Coal	2.96	3.26	3.25	3.51	3.14	3.33	3.38	4.17	3.56	3.27	4.07	3.71	3.68	3.85	4.02	4.08	4.14
Petroleum	10.95	10.33	10.30	10.54	10.83	10.69	11.27	11.69	12.39	12.78	12.27	11.77	12.43	13.83	14.36	13.21	12.22
Natural Gas	0.76	0.75	0.90	0.90	1.05	1.06	1.02	1.12	1.02	1.08	1.39	1.30	1.39	2.86	3.41	3.86	3.43
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Maine GHG Emissions

Emissions (MMTCO2E)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Energy	19.74	19.32	20.13	19.70	21.13	19.76	20.42	20.68	20.30	21.33	23.18	23.05	23.55	24.01	23.79	23.43	20.70	-
CO2 from Fossil Fuel Combustion	19.10	18.65	19.43	19.00	20.42	19.05	19.71	19.98	19.63	20.66	22.51	22.41	22.96	23.46	23.26	22.91	20.41	-
Stationary Combustion	0.25	0.27	0.29	0.28	0.28	0.29	0.29	0.28	0.26	0.27	0.28	0.26	0.25	0.24	0.24	0.25	0.04	-
Mobile Combustion	0.38	0.39	0.41	0.42	0.42	0.42	0.42	0.42	0.42	0.40	0.39	0.38	0.34	0.31	0.29	0.27	0.25	-
Coal Mining	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Natural Gas and Oil Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Industrial Processes	0.87	0.85	0.91	1.02	0.99	1.12	1.12	1.23	1.28	1.29	1.26	1.25	1.25	1.23	1.30	1.33	1.37	-
Agriculture	0.48	0.49	0.48	0.49	0.49	0.48	0.50	0.57	0.61	0.61	0.49	0.51	0.55	0.56	0.60	0.66	0.58	-
Enteric Fermentation	0.19	0.19	0.19	0.19	0.19	0.18	0.18	0.18	0.17	0.17	0.17	0.16	0.16	0.16	0.16	0.16	0.16	-
Manure Management	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.08	0.10	0.10	0.05	0.06	0.06	0.06	0.05	0.05	0.05	-
Rice Cultivation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agricultural Soil Management	0.24	0.25	0.25	0.25	0.25	0.25	0.27	0.32	0.34	0.34	0.27	0.30	0.33	0.35	0.39	0.45	0.37	-
Burning of Agricultural Crop Waste	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
LULUCF	9.05	9.04	9.04	9.38	9.37	3.12	(0.14)	(0.14)	(0.14)	(0.15)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.17)	5.54
Waste	0.47	0.50	0.52	0.40	0.43	0.41	0.43	0.42	0.52	0.50	0.52	0.55	0.54	0.52	0.49	0.56	0.44	0.13
Municipal Solid Waste	0.35	0.38	0.40	0.28	0.31	0.29	0.31	0.30	0.41	0.38	0.40	0.43	0.41	0.40	0.36	0.43	0.32	-
Wastewater	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.13
Gross Emissions	**30.60**	**30.20**	**31.09**	**30.98**	**32.41**	**24.89**	**22.48**	**22.90**	**22.72**	**23.73**	**25.45**	**25.37**	**25.90**	**26.32**	**26.18**	**25.98**	**23.09**	**5.67**
Sinks	**-**	**-**	**-**	**-**	**-**	**-**	**(0.14)**	**(0.14)**	**(0.14)**	**(0.15)**	**(0.16)**	**(0.16)**	**(0.16)**	**(0.16)**	**(0.16)**	**(0.16)**	**(0.17)**	**-**
Net Emissions	**30.60**	**30.20**	**31.09**	**30.98**	**32.41**	**24.89**	**22.34**	**22.76**	**22.57**	**23.58**	**25.30**	**25.21**	**25.74**	**26.16**	**26.02**	**25.82**	**22.92**	**5.67**

CO2 from Fossil Fuel Combustion

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Residential	3.03	3.04	3.05	3.18	3.26	4.00	4.13	3.97	4.28	4.07	3.95	3.96	3.53	4.74	5.22	4.75	4.13	-
Coal	0.02	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Petroleum	2.98	3.00	2.98	3.12	3.21	3.95	4.07	3.91	4.23	4.02	3.89	3.90	3.46	4.67	5.15	4.68	4.07	-
Natural Gas	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.07	0.08	0.07	0.07	0.06	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Commercial	2.18	2.16	1.73	1.68	1.71	1.41	1.55	1.55	1.60	1.48	1.78	1.45	1.79	2.16	2.10	1.92	1.68	-
Coal	0.08	0.03	0.07	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	-
Petroleum	2.01	2.03	1.54	1.50	1.57	1.27	1.40	1.40	1.46	1.34	1.60	1.28	1.44	1.85	1.81	1.64	1.38	-
Natural Gas	0.09	0.10	0.12	0.12	0.13	0.13	0.14	0.15	0.13	0.14	0.17	0.16	0.35	0.30	0.29	0.27	0.29	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Industrial	3.47	4.15	5.51	5.21	6.48	5.07	5.39	4.76	4.05	3.75	4.64	3.61	3.00	2.49	2.73	3.02	2.67	-
Coal	0.52	0.84	1.91	0.98	1.06	0.65	0.53	0.44	0.32	0.27	0.53	0.30	0.21	0.29	0.28	0.30	0.26	-
Petroleum	2.85	3.19	3.49	4.14	5.33	4.32	4.74	4.19	3.61	3.35	3.34	2.65	2.55	2.00	2.30	2.58	2.22	-
Natural Gas	0.11	0.12	0.11	0.09	0.09	0.11	0.12	0.13	0.12	0.13	0.77	0.66	0.24	0.21	0.16	0.15	0.19	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transportation	8.27	7.57	7.45	7.60	7.73	7.30	7.53	7.90	7.71	7.98	8.57	7.65	8.75	9.27	8.67	9.39	9.24	-
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum	8.27	7.57	7.45	7.60	7.72	7.30	7.53	7.90	7.71	7.98	8.53	7.58	8.69	9.22	8.63	9.36	8.97	-
Natural Gas	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.05	0.07	0.06	0.05	0.04	0.03	0.27	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electric Utilities	2.14	1.73	1.70	1.34	1.24	1.27	1.12	1.80	1.99	3.38	3.57	5.74	5.89	4.79	4.53	3.83	2.69	-
Coal	0.36	0.57	0.57	0.58	0.57	0.37	0.38	0.39	0.35	0.36	0.39	0.43	0.53	0.40	0.40	0.35	0.35	-
Petroleum	1.77	1.15	1.12	0.75	0.66	0.89	0.74	1.40	1.63	2.98	1.70	0.92	0.37	1.05	0.65	0.76	0.09	-
Natural Gas	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.03	1.47	4.39	4.99	3.33	3.48	2.71	2.26	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
International Bunker Fuels	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	-	-
Petroleum	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	-	-
TOTAL	19.10	18.65	19.43	19.00	20.42	19.05	19.71	19.98	19.63	20.66	22.51	22.41	22.96	23.46	23.26	22.91	20.41	-
Coal	0.98	1.44	2.57	1.63	1.65	1.03	0.92	0.84	0.68	0.64	0.93	0.73	0.74	0.70	0.68	0.66	0.62	-
Petroleum	17.88	16.94	16.58	17.10	18.49	17.72	18.48	18.80	18.64	19.67	19.06	16.33	16.51	18.79	18.54	19.02	16.73	-
Natural Gas	0.24	0.26	0.28	0.27	0.28	0.30	0.31	0.34	0.30	0.35	2.52	5.34	5.71	3.97	4.04	3.23	3.07	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Massachusetts GHG Emissions

Emissions (MMTCO2E)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Energy	85.84	84.71	86.64	83.91	84.12	81.23	82.35	88.53	86.36	83.68	84.69	83.90	84.83	85.82	84.54	86.11	76.27
CO2 from Fossil Fuel Combustion	83.92	82.73	84.60	81.87	82.08	79.19	80.26	86.49	84.36	81.82	82.86	82.17	83.28	84.34	83.13	84.75	75.19
Stationary Combustion	0.40	0.40	0.42	0.41	0.41	0.39	0.40	0.38	0.35	0.34	0.36	0.33	0.32	0.33	0.33	0.33	0.16
Mobile Combustion	1.52	1.57	1.63	1.62	1.64	1.65	1.69	1.67	1.66	1.52	1.47	1.40	1.23	1.15	1.09	1.03	0.93
Coal Mining	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Natural Gas and Oil Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Industrial Processes	0.59	0.56	0.59	0.75	0.93	1.29	1.50	1.74	1.92	2.12	2.29	2.31	2.48	2.61	2.75	2.87	2.96
Agriculture	0.38	0.37	0.38	0.37	0.36	0.36	0.35	0.35	0.33	0.32	0.33	0.32	0.32	0.33	0.34	0.36	0.30
Enteric Fermentation	0.14	0.13	0.13	0.13	0.13	0.12	0.12	0.11	0.11	0.11	0.10	0.09	0.10	0.09	0.09	0.09	0.09
Manure Management	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02
Rice Cultivation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agricultural Soil Management	0.21	0.20	0.21	0.21	0.20	0.20	0.20	0.21	0.18	0.19	0.20	0.20	0.20	0.21	0.22	0.24	0.19
Burning of Agricultural Crop Waste	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LULUCF	(5.56)	(5.58)	(5.61)	(5.73)	(5.75)	(5.77)	(5.80)	(6.98)	(10.51)	(10.53)	(10.55)	(10.57)	(10.60)	(10.62)	(10.64)	(10.66)	(10.68)
Waste	4.67	4.25	4.06	4.19	4.01	4.00	3.86	3.12	3.15	3.12	2.54	3.52	3.77	3.27	2.92	3.16	3.15
Municipal Solid Waste	4.11	3.68	3.49	3.61	3.44	3.42	3.27	2.54	2.56	2.53	1.92	2.90	3.15	2.65	2.30	2.53	2.53
Wastewater	0.57	0.57	0.57	0.57	0.58	0.58	0.58	0.58	0.59	0.59	0.61	0.62	0.62	0.62	0.62	0.62	0.62
Gross Emissions	**91.50**	**89.90**	**91.67**	**89.22**	**89.43**	**86.88**	**88.06**	**93.74**	**91.75**	**89.24**	**89.84**	**90.05**	**91.40**	**92.03**	**90.56**	**92.50**	**82.69**
Sinks	**(5.56)**	**(5.58)**	**(5.61)**	**(5.73)**	**(5.75)**	**(5.77)**	**(5.80)**	**(6.98)**	**(10.51)**	**(10.53)**	**(10.55)**	**(10.57)**	**(10.60)**	**(10.62)**	**(10.64)**	**(10.66)**	**(10.68)**
Net Emissions	**85.93**	**84.32**	**86.07**	**83.49**	**83.67**	**81.10**	**82.27**	**86.77**	**81.24**	**78.71**	**79.29**	**79.47**	**80.80**	**81.41**	**79.92**	**81.84**	**72.00**

CO2 from Fossil Fuel Combustion

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Residential	15.01	14.23	16.31	16.43	16.27	14.69	14.50	14.33	13.15	13.96	15.53	15.87	15.88	16.18	14.97	14.80	12.75	-
Coal	0.03	0.01	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.02	0.02	0.01	0.01	0.00	-
Petroleum	9.12	8.54	9.70	9.73	9.77	8.93	8.27	8.25	7.65	8.01	9.21	9.96	9.76	9.16	8.71	8.44	7.24	-
Natural Gas	5.86	5.67	6.59	6.69	6.50	5.75	6.22	6.07	5.49	5.94	6.32	5.91	6.09	7.00	6.25	6.35	5.51	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Commercial	8.40	9.18	8.93	7.96	8.85	8.94	9.02	9.41	8.02	6.14	6.69	5.67	5.86	7.00	6.56	6.59	1.30	4.90
Coal	0.12	0.06	0.11	0.09	0.05	0.06	0.07	0.06	0.06	0.09	0.04	0.03	0.18	0.11	0.07	0.09	0.01	0.03
Petroleum	5.50	6.19	5.27	4.26	4.21	4.40	3.72	3.63	3.11	2.39	3.13	2.22	2.07	3.42	3.33	3.46	0.83	2.10
Natural Gas	2.78	2.93	3.55	3.61	4.59	4.47	5.23	5.72	4.85	3.66	3.53	3.42	3.61	3.48	3.15	3.03	0.46	2.77
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Industrial	5.96	5.41	7.19	7.35	6.38	5.61	6.06	6.22	6.13	6.73	6.46	7.10	7.06	4.79	4.58	4.76	6.07	-
Coal	0.17	0.20	0.36	0.27	0.15	0.10	0.09	0.09	0.08	0.08	0.14	0.14	0.11	0.14	0.14	0.17	0.19	-
Petroleum	3.41	2.26	2.99	3.23	2.76	2.13	2.68	2.71	2.75	2.39	2.30	2.60	2.29	2.26	2.10	2.11	3.58	-
Natural Gas	2.38	2.96	3.84	3.85	3.47	3.38	3.29	3.42	3.30	4.26	4.02	4.36	4.66	2.39	2.34	2.47	2.30	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transportation	28.91	27.62	27.42	27.86	28.05	28.46	29.75	30.16	30.12	30.94	32.04	31.60	31.72	31.50	33.41	34.27	33.74	-
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum	28.85	27.54	27.32	27.74	27.95	28.35	29.63	30.02	30.01	30.79	31.91	31.42	31.48	31.38	33.30	34.14	33.61	-
Natural Gas	0.07	0.08	0.10	0.12	0.10	0.10	0.12	0.13	0.11	0.15	0.14	0.18	0.24	0.12	0.11	0.14	0.12	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electric Utilities	25.64	26.29	24.75	22.27	22.53	21.50	20.94	26.38	26.94	24.04	22.12	21.93	22.75	24.87	23.61	24.33	21.32	-
Coal	10.36	10.79	10.01	8.97	9.34	9.71	10.49	11.35	9.98	10.30	10.39	9.87	10.59	9.82	9.46	10.72	10.11	-
Petroleum	11.90	12.16	10.62	9.05	7.72	4.81	4.85	8.63	11.34	8.74	6.90	6.76	5.21	5.84	5.53	5.26	1.97	-
Natural Gas	3.38	3.34	4.12	4.24	5.47	6.98	5.60	6.39	5.62	5.01	4.83	5.29	6.94	9.22	8.62	8.35	9.24	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
International Bunker Fuels	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-
Petroleum	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-
TOTAL	83.92	82.73	84.60	81.87	82.08	79.19	80.26	86.49	84.36	81.82	82.86	82.17	83.28	84.34	83.13	84.75	75.19	4.90
Coal	10.68	11.06	10.52	9.35	9.54	9.88	10.66	11.51	10.13	10.47	10.57	10.05	10.91	10.08	9.68	11.00	10.31	0.03
Petroleum	58.77	56.69	55.89	54.01	52.40	48.63	49.14	53.24	54.86	52.32	53.45	52.97	50.82	52.05	52.98	53.42	47.24	2.10
Natural Gas	14.47	14.99	18.19	18.51	20.13	20.69	20.46	21.74	19.37	19.03	18.84	19.16	21.55	22.21	20.47	20.34	17.63	2.77
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Attachment #2

Spruce Mountain Tangible Benefits

PATRIOT RENEWABLES
Spruce Mountain Wind, LLC

Section 28
Tangible Benefits

PATRIOT RENEWABLES
Spruce Mountain Wind, LLC

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FIGURE

28.0 TANGIBLE BENEFITS

The Spruce Mountain Wind Project (Project) will provide tangible benefits to both the State of Maine and the host community of Woodstock, Maine, generating renewable energy without polluting the air and water. The Project will provide a significant contribution to the State of Maine to meet its goals for renewable energy development as described in 2007 Public Law, Chapter 661 ("the Wind Power Act") Under the terms of the Task Force legislation, as a renewable energy generation facility, the Project is presumed to provide energy and emissions related benefits. It will also help the state meet its commitments under the Regional Greenhouse Gas Initiative and help retail power suppliers meet their commitments under applicable Renewable Portfolio Standards.

28.1 Local Tangible Benefits

28.1.1 Conservation Land

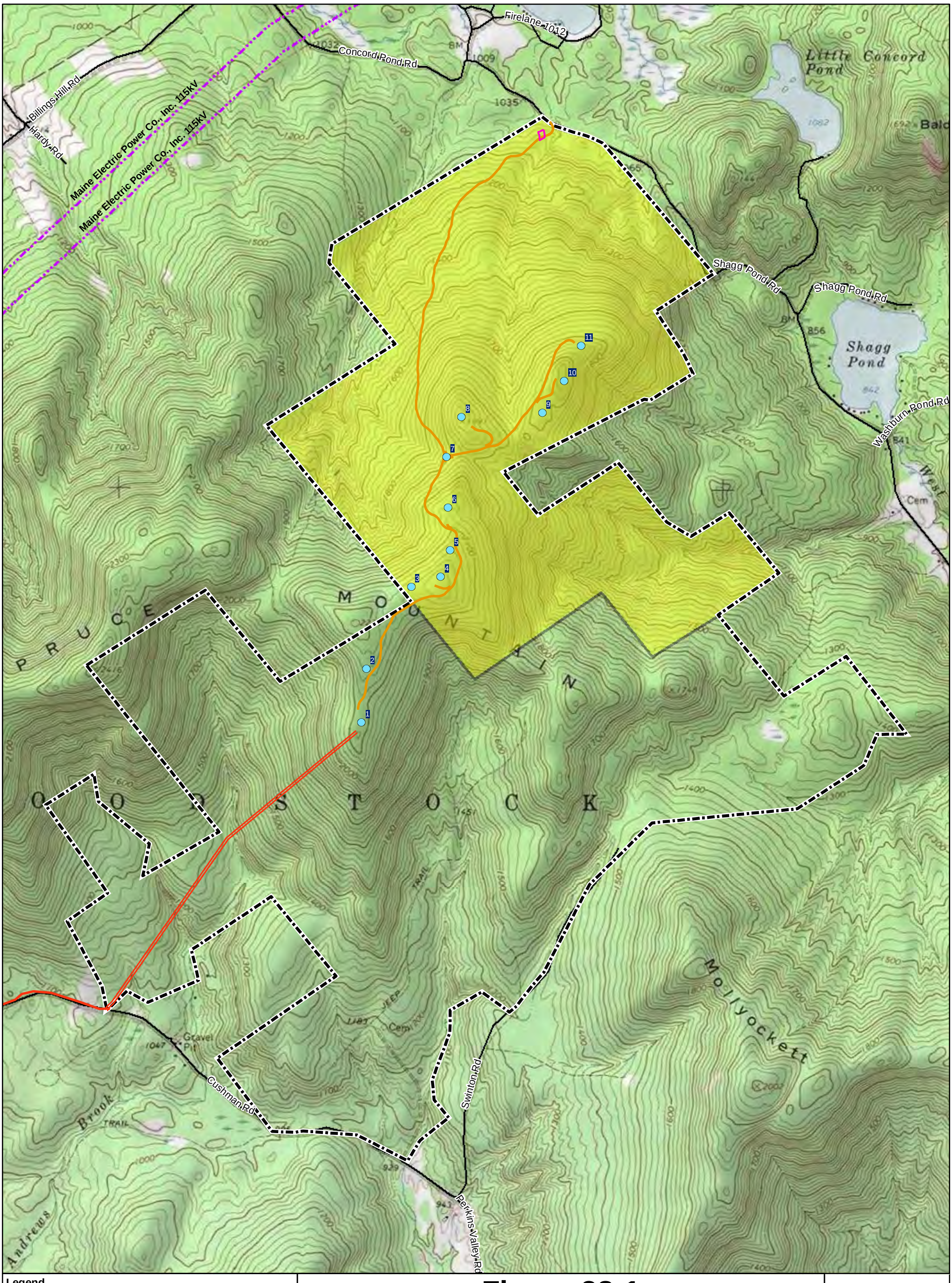
An affiliate of Spruce Mountain Wind, LLC (SMW) owns a large portion of project area land, enabling SMW to place up to 1,000 acres of the project area into conservation. A conservation easement on this acreage will allow for public use for recreational activities including hiking, hunting, fishing, and snowmobiling on appropriately located trails. This newly protected area will expand on existing conservation easements on abutting parcels and increase public accessibility to a larger contiguous undeveloped area. The conservation easement will allow for private sustainable forestry, but will prohibit further development. Figure 28-1 shows the conservation area being proposed by SMW.

28.1.2 Tax Benefits

The Project is expected to be assessed at approximately $37 million. This significant investment in the local community will make SMW the largest tax payer in Woodstock and will increase the assessment of the town by roughly 20 percent. Woodstock can elect to use the funds from the new tax revenue to lower taxes and/or fund public projects. The town can also choose to enter into a Tax Incremental Financing ("TIF") credit enhancement agreement with SMW, using funds generated by the TIF for municipal economic development projects to fuel job growth in the community. The Town of Woodstock and SMW are currently in discussions to evaluate the benefits of a TIF program to the town and to SMW. These include tax revenues retained by the town for approved uses, and a credit enhancement agreement with SMW that would lower power prices from the Project and increase funds available to the proposed community benefit fund. Woodstock residents would ultimately vote to approve any TIF agreements.

28.1.3 Employment

The Project will have a significant impact on employment in the state. Most consultants, contractors, and field crews currently working on development of the Project are based in Maine and employ Maine residents. SMW is committed to hiring local workers whenever possible and will endeavor to hire area contractors to construct the Project. During construction there will be job opportunities for activities such as tree clearing, excavation, road construction, concrete work, and electrical work. Materials located close to the site will be used as much as possible, giving local stone quarries and construction material suppliers procurement opportunities. In addition, local businesses such as motels, restaurants, gas stations, and retail stores will see increases in activity during construction. After construction is complete, the Project will employ a maintenance staff of two to three full-time workers. There will also be a need for on-going road maintenance, plowing, and landscaping services.



Legend

- Turbine Location (10-26-09)
- O&M Area
- Access Road
- Transmission Line
- Existing Transmission Line
- Project Boundary
- Owned Property (Proposed Conservation Area Limits)

0 0.25 0.5 Miles

Figure 28-1

Spruce Mountain Wind Project
Woodstock, Maine

Proposed Conservation Area Limits

December 2009

TETRA TECH EC, INC.

PATRIOT RENEWABLES
Spruce Mountain Wind, LLC

N W E S

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28.1.4 Community Benefit Fund

SMW has proposed to establish a Community Benefit Fund (CBF) that would provide the Town of Woodstock with an annual funding source that could be used by the community without restrictions. The CBF would be at least $20,000 per year for 20 years and would be administered by the Town of Woodstock. The size of this fund may increase subject to availability of project resources.

28.1.5 Emergency Equipment

SMW plans to use a tracked snow-cat to access the turbines and ridgeline during periods of heavy snow. The Town of Woodstock Fire Department has expressed an interest in having access to a snow-cat for emergency response use, and SMW has offered the town the use of the Project's snow cat for emergency response purposes. SMW will work with the town to train an operator from the fire department or will provide an operator from the project staff.

28.2 State and Regional Tangible Benefits

28.2.1 Electricity Pricing

Operation of the Project can help stabilize electricity prices and hedge against electricity price volatility and inflation. The Project is exploring various options for entering into a long-term, fixed-price power purchase agreement with a New England load-serving utility or end user, ideally with a Maine-based entity. A long-term, fixed-price contract ensures price stability for consumers. The use of renewable energy to generate electricity can play a significant role in offsetting price volatility in electric generation by providing a natural hedge against fuel supply constraints and natural gas cost volatility. In contrast to the volatility of natural gas prices, renewable resources provide a stable cost of electric generation and provide a suitable structure for a long term, fixed price contract[1]. Additionally, by diversifying the electric generation mix with increased domestic renewable energy, we enhance national security by decreasing our dependence on foreign fuel sources[2].

In addition, the cost of generating electric power from wind is not subject to market conditions that apply to traditional fossil fuel-based generation. Since the cost of fuel (wind) is free, wind turbine generators are always able to bid the lowest price in daily auctions, which has the effect of displacing higher priced, marginal power sources like natural gas fired generators, thus lowering the average cost of energy on the grid.

28.2.2 Environmental Benefits

An 18-MW project at Spruce Mountain would provide enough emission-free renewable energy for approximately 8,700 Maine households each year[3].

Wind energy generation facilities use a pollution-free fuel that causes no ancillary pollution from extraction or transport of fuel or disposal of waste by-products. Therefore, Maine law presumes that renewable energy projects provide emissions-related benefits to the state and the surrounding regions. As was stated by the Governor's Task Force on Wind Development, a group formed by Governor Baldacci in May 2007 to assess the potential for wind development in Maine, "Two of the major, energy-related

[1] *White Paper*. U.S. Department of Energy. June 2004
[2] *20% Wind Energy by 2030*. U.S. Department of Energy. July 2008
[3] Based on a 35% capacity factor and an annual electricity usage of 6,335 kWh per year per Maine household.

challenges that Maine is facing are the need to reduce greenhouse gas emissions and the need to increase the reliability of our electricity supply. Wind power holds great promise in helping meet each of these challenges."[4] By incorporating renewable energy into Maine's energy grid it is possible to minimize the production of fossil fuel by-products such as sulfur dioxide, nitrogen oxide, carbon dioxide (one of the major contributors to global warming), and mercury, which currently poses a serious threat to the Common Loon and region-wide fish populations.[5]

28.2.3 Health Benefits

According to the Maine Center for Disease Control (CDC), "Generating energy from wind turbines means less energy generated from foreign oil and coal, both being major contributors to global warming, pollution, and resulting diseases and deaths due to heart disease, cancer, asthma, and other lung diseases. Maine's highest-in-the-nation rates of asthma and cancer are thought to be at least partially due to pollution from our dependence on fossil fuels." [6]

28.3 Conclusion

SMW has worked closely with local and state agency representatives throughout the siting and development process to integrate regional and local needs into the proposed Project. The Project will provide increased employment during construction, local tax benefits, a community benefits fund and local and regional environmental benefits—all significant tangible benefits to the State of Maine and the Town of Woodstock.

[4] Report of the *Governor's Task Force on Wind Development*. February 2008. http://www.maine.gov/doc/mfs/windpower/pubs/report/wind_power_task_force_rpt_final_021408.pdf
[5] *If Not Wind, Then What?* Natural Resources Council of Maine. http://www.nrcm.org/if_not_wind.asp
[6] Mills, Dora Anne, MD, MPH Maine CDC/DHHS *Are Wind Turbines Health Hazards?* June 2009. http://www.maine.gov/dhhs/boh/wind-turbines.shtml

Attachment #3

Saddleback Ridge Tangible Benefits

PATRIOT RENEWABLES
Saddleback Ridge Wind, LLC

Section 28
Tangible Benefits

PATRIOT RENEWABLES
Saddleback Ridge Wind, LLC

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28.0 TANGIBLE BENEFITS

The Saddleback Ridge Wind Project (Project) proposed by Saddleback Ridge Wind, LLC (SRW) will provide tangible benefits to both the state of Maine and the host community of Carthage, Maine, generating renewable energy without polluting the air and water. The Project will provide a significant contribution to the state of Maine to meet its goals for renewable energy development as described in 2007 Public Law, Chapter 661 ("the Wind Power Act"). Under the terms of the Task Force legislation, the Project, as a renewable energy generation facility, is presumed to provide energy and emissions related benefits. It will also help the state meet its commitments under the Regional Greenhouse Gas Initiative and help retail power suppliers meet their commitments under applicable Renewable Portfolio Standards.

28.1 Local Tangible Benefits

28.1.1 Tax Benefits

The Project is expected to be assessed at approximately $66 million. This significant investment in the local community will make SRW the largest taxpayer in Carthage and will increase the assessment of the town by roughly 180 percent. Carthage can elect to use the funds from the new tax revenue to lower taxes and/or fund public projects. The town can also choose to enter into a Tax Incremental Financing (TIF) agreement with SRW, using funds generated by the TIF for municipal economic development projects to fuel job growth in the community.

28.1.2 Employment

The Project will have a significant impact on employment in the state of Maine. Most consultants, contractors, and field crews currently working on development of the Project are based in Maine and employ Maine residents. SRW is committed to hiring local workers whenever possible and will endeavor to hire area contractors to construct the Project. During construction, there will be job opportunities for activities such as tree clearing, excavation, road construction, concrete work, and electrical work. On average, the Project would employ 60 to 70 construction workers for five to six months and up to 100 workers during peak construction times. Materials located close to the site will be used as much as possible, giving local stone quarries and construction material suppliers procurement opportunities. In addition, local businesses such as motels, restaurants, gas stations, and retail stores will see increases in activity during construction. After construction is complete, the Project will employ a maintenance staff of two to three full-time workers. There will also be a need for ongoing road maintenance, plowing, and landscaping services.

28.1.3 Community Benefit Fund

SRW will establish a Community Benefit Fund (CBF) that would provide the town of Carthage with an annual funding source that could be used by the community without restrictions. SRW would fund at least $4,000 per turbine per year for the life of the Project, and the size of this fund may increase subject to availability of project resources. The CBF would be administered by the town of Carthage.

28.1.4 Recreation

SRW will donate $60,000 to the Maine Bureau of Parks and Lands to be used for a new playground at the beach and campground near Webb Lake in Mount Blue State Park.

28.2 State and Regional Tangible Benefits

28.2.1 Electricity Pricing

SRW is exploring various options for entering into a long-term, fixed-price power purchase agreement with a New England load-serving utility. In contrast to the volatility of natural gas prices, renewable resources provide a stable cost of electric generation and provide a suitable structure for a long-term, fixed price contract[1]. This, in turn, increases price stability for utility customers, which makes it an attractive component of a utility's supply portfolio. In addition, by diversifying the electric generation mix with increased domestic renewable energy, we enhance national security by decreasing our dependence on foreign fuel sources[2].

In addition to the fixed price and energy independence benefits, wind projects will lower the average wholesale price of electricity in the regional market. Every day, all electricity generators in New England submit bids into the daily market to win the right to generate power. Because the market can produce more generation than is needed to meet consumer demand, the highest priced generators are not selected. All of the winning bidders receive the same price—the market clearing price—which is set by the highest winning bid. Coal and gas generators need to burn fuel to operate, so they must bid a price high enough to at least cover their fuel costs; otherwise, they will lose money every second they generate power. Wind turbines have free fuel (wind), so wind generators can bid zero, ensuring a winning bid and knocking out a higher-priced generator and lowering the market clearing price. Therefore, as more wind and other low cost energy enters the market, more high cost generators will be unable to compete, resulting in lower market clearing prices for electricity.

28.2.2 Environmental Benefits

A 33-MW project at Saddleback Ridge would provide enough emission-free renewable energy for more than 16,000 Maine households each year[3].

Wind energy generation facilities use a pollution-free fuel that does not create ancillary pollution from extraction or transport of fuel or disposal of waste by-products. Therefore, Maine law presumes that renewable energy projects provide emissions-related benefits to the state and the surrounding regions. As stated by the Governor's Task Force on Wind Development, a group formed by Governor Baldacci in May 2007 to assess the potential for wind development in Maine, "Two of the major, energy-related challenges that Maine is facing are the need to reduce greenhouse gas emissions and the need to increase the reliability of our electricity supply. Wind power holds great promise in helping meet each of these challenges."[4] By incorporating renewable energy into Maine's energy grid, it is possible to minimize the production of fossil fuel by-products such as sulfur dioxide, nitrogen oxide, carbon dioxide (one of the major contributors to global warming), and mercury, which currently poses a serious threat to the Common Loon and region-wide fish populations.[5]

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[1] *White Paper*. U.S. Department of Energy. June 2004
[2] *20% Wind Energy by 2030*. U.S. Department of Energy. July 2008
[3] Based on a 35% capacity factor and an annual electricity usage of 6,211 kWh per year per Maine household.
[4] Report of the *Governor's Task Force on Wind Development*. February 2008.
http://www.maine.gov/doc/mfs/windpower/pubs/report/wind_power_task_force_rpt_final_021408.pdf
[5] *If Not Wind, Then What?* Natural Resources Council of Maine. http://www.nrcm.org/if_not_wind.asp

28.2.3 Health Benefits

According to the Maine Center for Disease Control (CDC), "Generating energy from wind turbines means less energy generated from foreign oil and coal, both being major contributors to global warming, pollution, and resulting diseases and deaths due to heart disease, cancer, asthma, and other lung diseases. Maine's highest-in-the-nation rates of asthma and cancer are thought to be at least partially due to pollution from our dependence on fossil fuels."[6]

28.3 Conclusion

SRW has worked closely with local and state agency representatives throughout the siting and development process to integrate regional and local needs into the proposed Project. The Project will provide increased employment during construction, local tax benefits, a community benefits fund, money for the enhancement of Mount Blue State Park, electricity price stability, downward pressure on wholesale spot market prices, and local and regional environmental benefits—all significant tangible benefits to the state of Maine and the town of Carthage.

[6] Mills, Dora Anne, MD, MPH Maine CDC/DHHS *Are Wind Turbines Health Hazards?* June 2009. http://www.maine.gov/dhhs/boh/wind-turbines.shtml

Attachment #4

Kibby II Tangible Benefits

Kibby II Tangible Benefits

13. *Applicant's tangible benefits proposal.* The applicant asserted the following regarding the tangible benefits associated with the proposed revised KEP:

A. *Economic benefits.* The applicant asserted that the proposed revised KEP would provide significant economic benefits for Maine and the region, and they expect the benefits to be similar to the actual benefits resulting from the existing Kibby Project. As of December 2009 the Kibby Project had resulted in $109 million spent in Maine, of which $9 million was spent in Franklin and Somerset Counties. During peak construction during the summer of 2009, 315 workers were employed, of which 80% were from Maine. The actual construction period data from the Kibby Project were consistent with predictions by State economist Charles Colgan during review of that project (reference Zoning Petition ZP 709).

In addition, the applicant asserted the following:

(1) Direct and indirect employment during construction of the proposed revised KEP would include both temporary construction industry jobs, and indirect support of local businesses. Maine companies such as construction or environmental companies that were used for the Kibby Project have already been or are expected to be used for the revised KEP.

(2) For the proposed revised KEP, 1 additional permanent employee would be needed. Nine people from Maine (most from Franklin County) were hired for the Kibby Project A Series, with more hired as the B Series came on-line in the fall of 2010.

(3) The benefits to energy security and costs cannot be analyzed using econometric models. The KEP will sell to New England market, but market stability is affected by world fossil fuel markets. However, wind energy tends to stabilize prices, mitigating other destabilizing forces.

(4) Several real property taxes and local benefits were noted:

(a) *Property taxes*. Additional property revenues over the life of the project, paid to the State's General Fund would be paid. Although the exact tax value of the KEP has not yet been determined, the applicant is the largest single tax payer in Franklin County, and estimates it will pay more than $400,000 per year in property taxes to the Unorganized Territories, or $10 million over a 25-year period, for the revised KEP.

(b) *State income taxes*. There would be additional State income tax revenues paid over the life of the project, estimated to be at least $13 million over a 25-year period.

(c) *Community benefits package*. The community benefits package to Eustis/Stratton would be increased from $132,000 to $165,000 for the additional 33 MW ($1,000 per MW). The community benefits package would be equivalent to $4,000 per turbine per year over a 25 year period, for a cumulative package of $880,000, and would consist of:

(i) $33,000 per year payable to the Town of Eustis/Stratton, or $660,000 over 20 years (reduced from $45,000 per year in the original proposal)
(ii) $110,000 lump sum payment to the Maine Department of Labor to support green job education and training in Franklin County (reduced from $150,000 in the original proposal);
(iii) $110,000 lump sum payment to the High Peaks Alliance (HPA) to support land conservation and trail corridor acquisition in Franklin County (reduced from $150,000 in the original proposal).

Attachment #5

Bull Hill Tangible Benefits

TANGIBLE BENEFITS SECTION FROM DRAFT BULL HILL APPLICATION 12/10/10

22.0 TANGIBLE BENEFITS

The project will provide significant tangible benefits to Hancock County, as well as to the entire State of Maine.[1] Tangible benefits are defined as environmental or economic improvements or benefits to residents of the State attributable to the construction, operation, and maintenance of the project and include, but are not limited to, property tax payments resulting from the development; other payments to a host community, including, but not limited to, payments under a community benefits agreement; construction-related employment, local purchase of materials, employment in operations and maintenance, reduced property taxes, reduced electrical rates, land or natural resource conservation, performance of construction, operations, and maintenance activities by trained, qualified and licensed workers, or other comparable benefits. 38 M.R.S.A. § 3451(10). There is no requirement in the statute that a project include benefits in each of the specified areas, but rather that the collective benefits from the project be significant. Id. On the local level, the benefits are lease payments for land, employment opportunities, the local purchase of materials and supplies, taxes paid on the project, and an annual Community Benefit Fund payment.

On a larger scale, the project will increase energy diversity, thereby helping to reduce electric price volatility in Maine. The project will also help Maine meet its commitments under the Regional Greenhouse Gas Initiative (RGGI), which establishes limits for emissions associated with the generation of electricity. The project includes a myriad of environmental and economic benefits that constitute tangible benefits under the Wind Power Act and collectively are significant. The U.S. Department of Energy recently evaluated and affirmed that wind power will bring these very benefits to Maine. (http://www.windpoweringamerica.gov/pdfs/economic_development/2008/me_wind_benefits_factsheet.pdf).

22.1 ECONOMIC BENEFITS

22.1.1 Local Landowner Benefits

The project provides a direct economic benefit to the local landowners participating in the project through land leases and easements. The project allows these landowners to capture a new resource to gain economic benefits from their land and will produce steady annual revenue to the landowner with turbines on the property during the life of the project. This income stream can supplement what the landowners typically make from logging and other uses of the land and represents a significant economic benefit. This additional income stream for these commercial forestlands will help maintain the property in traditional forestry and recreational uses, while creating a new source of clean energy.

22.1.2 Increased Employment

Measures of Hancock County's economic climate are below the State average, signaling the need for investment and economic development. The 2009 average annual income for the State of Maine was $36,803; Hancock County's average income of $32,468 is below that state average. While Hancock County's August 2010 un-adjusted unemployment rate of 6.1 percent is below Maine's un-adjusted rate of 6.9 percent for the same month, a closer look demonstrates Hancock's dramatic seasonal employment pattern. Reflecting the seasonality of the local service economy, the County generally stays below the state unemployment average during the months of May to September, but spikes to several percentage points above the state average during October to April. In addition, the total number of people employed in Hancock County has been declining since 2008.[2]

The Project would respond directly to area needs and to the people who live and work in the vicinity of T16 MD. A significant portion of the estimated $78.5 million dollar project cost is expected to be spent on

[1] See 35-A M.R.S.A. §3454 and 38 M.R.S.A. §484(3) for relevant criteria.
[2] Maine Department of Labor, Center for Workforce Research and Development.

development, engineering, and construction-related activities, much of which is anticipated to stay within Maine. The surrounding areas can benefit through construction-related employment opportunities and the ancillary economic benefits of that construction activity. There will be the opportunity for direct jobs for activities like tree clearing and excavation, and ancillary jobs in businesses that support construction such as lodging, restaurant, fuel and concrete supply. For the Mars Hill, Stetson, and Stetson II projects combined, more than 850 people were employed during construction. Based on First Wind's experience developing and constructing facilities with a total capacity of 125 MW of wind energy in Maine, development and construction of the proposed Bull Hill project will require the direct labor of approximately 225 individuals (or 65 full-time equivalent jobs). Following the construction phase, Blue Sky anticipates hiring three to eight permanent employees to operate and maintain the facility. First Wind now directly employs 32 people to support ongoing development, project management, and operations of operating and proposed wind facilities. The project will hire locally whenever possible, providing construction, operations, and maintenance employment opportunities to community residents.

The economic benefits of a wind project are significant and can provide value and stability to the local and regional economy. Although the exact amount of direct and indirect economic benefits of the project may be difficult to predict, the actual economic spending associated with the development and construction of the nearby Stetson Wind Project is evidence of the tangible economic benefits that can be expected from this project. Included as Exhibit 22 is a graphic representing the local and statewide economic benefits associated with the Stetson Wind Project and a list of Maine companies benefiting from that project. As indicated in that graphic, of the approximately $65 million spent for construction, engineering, and development services, about $50 million was spent with Maine businesses, with approximately 350 people directly engaged in construction of the project. Another $23 million was spent locally and in Maine for construction of the Stetson II project. Contractors throughout the state from Fryeburg to Presque Isle, consultants with offices throughout the state, and local businesses in the Lincoln and Danforth area all benefited from these expenditures. These amounts reflect only direct spending by the developer and do not capture the indirect jobs and benefits that may result from that direct spending. For example, the contractors hired by the developer to build the project will spend money on food, lodging, and fuel in the area. Similar benefits during construction are also expected for the Bull Hill Wind Project.

22.1.3 Reduced Local Property Taxes

Utility-scale wind power projects require large capital investments that have been estimated from $95 million to $270 million.[1] The large investment in a wind power project can result in a dramatic increase in real property value, and typically has the corresponding effect of substantially increasing the local property tax base. The applicant expects that it will pay significant annual property taxes on the project.

Host communities to large projects with high taxable value, such as a grid-size wind power project, enjoy tangible benefits related to the taxes paid on these projects, and can select the manner in which the community wishes to enjoy those benefits. Some communities choose to use the new property taxes to reduce local property taxes. As an example, the mil rate in Mars Hill decreased significantly (from $25.00 to $20.00) in 2007 as a result of the tax payments associated with the Mars Hill wind power project. Under the terms of a Tax Increment Financing (TIF) agreement, Evergreen Wind Power, LLC (an affiliate of this Applicant) pays the Town of Mars Hill $500,000 in property taxes annually, and will continue to pay that amount annually through 2026. In total, First Wind is paying more than $1.1 million annually in property tax payments for its Mars Hill and Stetson wind power projects, each of which is subject to a 20-year TIF reimbursement arrangement with the host community. Thus, TIF agreements such as that between the Town of Mars Hill and Evergreen Wind Power, LLC, can provide long-term stability, predictability, and property tax relief to a community arising from the substantial property tax payments associated with commercial wind power facilities.

Other host communities choose to enjoy their tangible tax-related benefits by segregating the new property taxes in a TIF program and by using the community's share of those new taxes to fund economic

[1] *The Benefits, the Quid Pro Quos for Fashioning a Streamlined Approach to Commercially Sized Wind Energy Facility Siting*, Orlando E. Delogu, Emeritus Professor of Law, University of Maine School of Law, January 2008.

development projects that have been approved by the legislative body of the of the governmental entity and the State of Maine Department of Economic and Community Development.[2] As an example, the Washington County Commissioners created a 30-year TIF around both phases of the Stetson Wind Power Project (the Stetson TIF), allowing the County to use a significant portion of the project's property taxes to fund economic development projects within the unorganized territories of Washington County. As part of its TIF program, the County also entered into 20-year TIF agreements with Evergreen Wind Power V, LLC, and Stetson Wind II, LLC (affiliates of this Applicant). The Stetson TIF will provide an average annual payment of approximately $301,226 to Washington County for the County's use in funding a wide variety of economic development projects over a 30-year period.[3]

For the Oakfield Wind Project, the Town of Oakfield designated a TIF district and adopted a Development Program for the TIF district relating to the original Oakfield Wind Project. The Town set out a plan of municipal economic development-related projects that it intends to complete with the municipal TIF revenues. Some of the municipal projects to be funded with municipal TIF revenues, as approved by the Town and the State Department of Economic and Community Development, include a public safety building and equipment, road reconstruction, public works equipment, village infrastructure and business assistance, and resident training.

Blue Sky estimates that the Bull Hill Wind Project will add approximately $69 million of new property tax value to the unorganized territory of Hancock County, resulting in estimated average annual tax payment of approximately $342,343 dollars (averaged over a 20-year period), adjusted by any credit enhancement agreement.

Blue Sky is currently discussing the development with the Hancock County Commissioners, and is proposing a TIF district around the project. As part of a TIF, Blue Sky would enter into a credit enhancement agreement in which it would recoup some portion of the annual tax payment estimated above. By creating a TIF district, the County would have the ability to obtain tax revenue that would have gone directly to the state. The County would then be able to use a significant portion of the project's property taxes to fund a wide variety of economic development projects throughout Hancock County's unorganized territory. Approved county TIF programs in other counties include the purchase of emergency communications equipment, road improvements, scenic by-way enhancements, nature-based tourism planning, county matches for economic development grants, and revolving loan funds for county residents and businesses.

22.1.4 Reduced Energy Price Volatility

The addition of new power generation facilities in Maine will tend to lead to lower and less volatile electricity prices. This is particularly true in the case of the addition of renewable power facilities like wind projects. The price and reliability benefits of new renewable resources have been described by the Maine Public Utilities Commission (MPUC) as follows:

> *The addition of diverse (non-gas) resources in Maine and elsewhere in the region will be beneficial for several reasons. As more non-gas generation is added to the mix, cheaper gas resources and non-gas resources will set the clearing prices in a greater number of hours.* ***This would have the general effect of reducing both the level and volatility of electricity prices throughout the region. To the extent new generation is constructed within Maine's borders, the benefit to Maine consumers is more direct in that the result would be lower prices within the Maine zone****. In addition, any overall reduction in the demand for gas that results from the addition of non-gas resources in the region should have the effect of reducing the price of natural gas which translates into lower electricity prices. Finally, a*

[2] In an unorganized territory, the county acts in the place of the municipality in creating and implementing a TIF program. 30-A M.R.S.A. § 5235.

[3] The County created a 30-year TIF around the Stetson project, but entered into 20-year reimbursement agreements with the two First Wind entities.

reduction in the region's reliance on natural gas would result in a more secure system that is less vulnerable to gas shortages and thus less susceptible to curtailments and blackouts.[4]

Given that the cost of generating wind power is stable and is not subject to fluctuations in fossil fuel prices, the development of new wind facilities like the project will also create an opportunity to reduce price volatility directly for certain consumers. In addition to opportunities to work directly with consumers, the cost stability of wind energy makes it a strong candidate for long-term contracts.

Additionally, a number of states in New England, including Maine, have adopted some type of Renewable Portfolio Standards (RPS) to diversify the electricity supply portfolio, stabilize rates, increase energy security, improve environmental quality, invigorate the clean energy industry, and promote economic development. Essentially, RPS create a statutory requirement for clean power, and the Maine Legislature has reaffirmed its support for the Maine RPS—and in fact expanded it—in recent sessions. The combined effect of the RPS in New England is an increasing regional demand for renewable energy that far exceeds the currently available and qualifying supply of renewable energy. This 34.2-MW project is estimated to produce an approximate average annual output of 94,000 MW/hours per year, and thereby take an important step toward achieving the policy objectives of the Maine RPS law. The Mars Hill and combined Stetson Wind Projects are already generating a total of approximately 377,000 MW hours per year.

22.1.5 Community Benefits Package

Blue Sky is required to provide a community benefits package that is valued at no less than $4,000 per turbine per year to the host community or communities. 35-A M.R.S.A. §3454(2). To satisfy this requirement, Blue Sky proposes a package of benefits to the host and adjacent communities, paid annually for each year of project operation. First, Blue Sky would execute a Community Benefit Agreement with the Hancock County Commissioners equal to the $4000 per turbine per year. In addition, Blue Sky has also offered the adjacent Town of Eastbrook an unrestricted annual payment of $30,000. Finally, an additional $10,000 annual payment would be made to establish a fund for the improvement and preservation of water quality in Molasses Pond, Spectacle Pond, and Narraguagas Lake. This fund would be administered by the Eastern Maine Development Corporation.

22.2 ENVIRONMENTAL BENEFITS

Electricity generation from wind energy projects results in zero air or water pollution. Each clean MW produced by wind energy displaces generation from more costly and polluting fossil fuels. To put this into perspective, a traditional fossil fuel burning power plant would have burned approximately 288,000 barrels of oil or 61,000 tons of coal per year to produce an amount of energy equivalent to the clean energy produced last year at the 42 MW (nameplate capacity) Mars Hill Wind project in Mars Hill, Maine. However, wind energy generation results in none of the associated toxicity, pollution and public health issues associated with traditional fossil fuel energy sources. Based on data published by the U.S. Environmental Protection Agency for 2005 regional emissions, traditional New England generation sources producing an equivalent annual amount of electric energy to the amended project would emit approximately 127,746 metric tons of carbon dioxide, 5,164 pounds of nitrous oxide, and 323 metric tons of sulfur dioxide.

Maine and the region have set aggressive greenhouse gas reduction goals. State and regional experts, including the MPUC and ISO-New England, have concluded that Maine and the region cannot meet these greenhouse gas policy goals without significant additions of wind power and other renewable energy sources in Maine and elsewhere.[5] For instance, RGGI may be more costly to implement unless a substantial amount of wind power is built.

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[4] MPUC Review Comments for the Land Use Regulation Commission, Zoning Petition ZP 702 (Maine Mountain Power, LLC), April 14, 2006, page 4.

[5] *New England Energy Market and Wind Power in Maine*, MPUC presentation to the Wind Power Task Force, August 3, 2007.

The significant environmental benefits associated with wind power, including avoided air pollution benefits, were recently recognized by the Governor's Task Force on Wind Power Development, and affirmed by the Legislature with enactment of "An Act to Implement the Recommendations of the Governor's task Force on Wind Power Development, Public Law 2008, Chapter 661."[6]

22.3 CONCLUSION

The "*environmental or economic improvements attributable to the construction, operation and maintenance of the [Bull Hill] project*" constitute a significant tangible benefit under the Wind Power Act. The collective impact of the construction-related employment, local purchase of materials, employment in operations and maintenance, and direct payment to host communities through the Community Benefits Agreement provides significant tangible benefits to Hancock County and the State of Maine.

[6] See e.g., 35-A MRSA §3402(1).

Attachment #6

Highland Wind Tangible Benefits

Section 21
Tangible Benefits

21.0 TANGIBLE BENEFITS

35-A MRSA §3454 requires an applicant for a grid-scale wind energy project to provide energy and emissions-related "tangible benefits"[1] and, as a subset of tangible benefits, a community benefits package.[2] 35-A MRSA §3454(1) sets forth certain documentation regarding tangible benefits that an applicant must include in any permit application; this information is set forth below.

In addition, pursuant to the statutory language contained in 35-A MRSA §3454(1) that states that "the applicant may submit the information required under paragraph D ["a description of the community benefits package..."] as an addendum to the permit application during the period in which the application is pending," Highland Wind hereby notifies the Land Use Regulation Commission (LURC) that it intends to submit supplemental information regarding paragraph D of 35-A MRSA §3454(1), including proposed implementing legal documents (e.g., document extinguishing right to development wind power on Stewart Mountain) at an appropriate later date during the period in which the application is pending but sufficiently in advance of any hearing before LURC so that the staff, Commission and other parties to this proceeding are fully aware of this information and can review it prior to any pre-filed testimony deadline.

21.1 Documentation Required

An expedited wind energy development permit, pursuant to 35-A MRSA §3454 (1) must provide documentation of tangible benefits as follows:

> "A. Estimated jobs to be created statewide and in the host community or communities, as a result of construction, maintenance and operations of the project;
> B. Estimated annual generation of wind energy;
> C. Projected property tax payments;

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[1] "Tangible benefits," as defined by the Act, means "environmental or economic improvements or benefits to residents of this State attributable to the construction, operation and maintenance of an expedited wind energy development, including but not limited to:

- Property tax payments resulting from the development;
- Other payments to a host community, including, but not limited to, payments under a community benefit agreement;
- Construction-related employment;
- Local purchase of materials;
- Employment in operations and maintenance;
- Reduced property taxes;
- Reduced electrical rates;
- Land or natural resource conservation;
- Performance of construction, operations and maintenance activities by trained, qualified and licensed workers in accordance with Title 32, chapter 17 and other applicable laws [note: this items refers to the use of licensed electricians on the project]; or
- Other comparable benefits, with particular attention to assurance of such benefits to the host community or communities to the extent practicable and affected neighborhood communities." (35-A M.R.S.A. §3451 (10))

[2] The community benefits element of tangible benefits must be a package that is valued at no less than $4,000 per year per wind turbine, averaged over a 20-year period. This value is in addition to the property tax obligations of the wind energy development. The community benefits package must consist of any of the following:

> "A. Payments, not including property tax payments, to the host community or communities, including, but not limited to, payments under community benefit agreements;
> "B. Payments that reduce energy costs in the host community or communities; and
> "C. Any donations for land or natural resource conservation." (35-A M.R.S.A. §3451 (1-C))

A "community benefit agreement," referred to in A. in the definition above, is an optional agreement between the developer and the host community that allows payments from the developer to be used for any public purpose specified in the agreement. (35-A M.R.S.A. §3451 (1-B). As described in this Section 20.2, Highland Wind's community benefits package, which is valued at $4,000 per year per wind turbine, focuses on reducing energy costs and reliance on fossil fuel combustion in the host community, and on land conservation, neither of which requires a separate community benefit agreement.

D. A description of the community benefits package, including but not limited to community benefit agreement payments….; and
E. Any other tangible benefits to be provided by the project."

21.2 Tangible Benefits Provided

The Highland Wind project will provide the following tangible benefits, which are presented in the order (A through E) listed in the statute.

A. ***Jobs Created***: Engineering, design, permitting and construction are estimated to occur over a 6-year period. According to an analysis by University of Southern Maine economist Charles Colgan (attached hereto as Appendix 21-1), over this planning and construction period, employment in Maine associated with the project will peak at more than 330 jobs during the primary construction year and, during the non-peak years, will average about 36 jobs per year. Highland Plantation is at the boundary of what the economic model refers to as the Kennebec and Western Maine regions, and most of the jobs will be within these regions, including all of the peak construction year jobs. Following construction, an estimated 8 permanent jobs will be created to operate and maintain the project. These employees will be located in a facility to be built in Highland Plantation.

The Wind Energy Act includes use of licensed electricians in the construction and maintenance of the project as a specific type of tangible benefit. Based on comparable projects in Maine, it is projected that the construction of the Highland Wind project will utilize about 80 licensed electricians for the construction of collector lines and the project's substation.

B. ***Estimated Annual Generation of Wind Energy:*** Highland Wind's 39 turbines will have an installed capacity of between 90 and 117 megawatts, which represents 4.5 percent to 6 percent of the statewide goal of 2000 megawatts of installed wind power capacity by 2015. Actual production is projected at 306,000 to 350,000 megawatts/hour/year (MW/hr/yr), which represents the electricity requirements of 41,000 to 47,000 Maine homes.

C. ***Projected Property Tax Payments:*** The cost of developing Highland Wind is estimated at between $210 million and $247 million. Assuming that assessed value for purposes of property taxation is approximately 80 percent of project cost, the local assessed value of Highland Plantation will increase in the first full year of valuation by between $168 million and $198 million. This represents a 20- to 24-fold increase in the Plantation's existing (2010) assessed value of about $8.3 million and will have a dramatic, beneficial effect on the local property tax rate.

In most other wind power projects in Maine, the community or county and developer have established tax increment finance districts (1) to shelter the increase in assessed value from losses under school aid and municipal revenue sharing formulas and increases in the local share of county taxes and (2) to return a portion of new property taxes to the developer to help finance the project. State law does not allow tax increment financing in plantations, and in any case the developers of Highland Wind have not in the past sought so-called "credit enhancement agreements" to subsidize their projects. As a result, Highland Plantation will see a large benefit in property taxes but, through state and county redistribution formulas, state and county taxpayers also will share in some of these benefits.

State valuations, which are used to "equalize" tax calculations statewide, typically are two years behind local valuations, and the tax shifts relating to school aid, revenue sharing, and county taxes also take two years to "catch up" and to be reflected in the local budget. Initially, therefore, based on Highland Plantation's 2010 budget, it is estimated that Highland Wind will pay to Highland Plantation property taxes of between $118,000 and $119,000 per year, depending on actual project costs. This will be the great majority of all property taxes paid in the plantation.

Once state valuations catch up and Highland Plantation's 2010 budget is adjusted to account for losses in school aid and municipal revenue sharing and the Plantation's increased share of county taxes, it is estimated that Highland Wind will pay to Highland Plantation property taxes of between $469,000 and

$526,000 per year.[3] Again, this will be the great majority of all property taxes paid in Highland Plantation. Collectively, if the Plantation's 2010 budget stayed the same as in 2010, all other Highland Plantation taxpayers would see their contributions to the expenses of the Plantation drop from $123,900 per year to about $23,000. Over time, the analysis assumes that Highland Wind's facilities will depreciate in value at about three percent per year.

As a result:

- Highland Plantation will see its mill rate drop from a little under $15 per thousand dollars of assessed value (as of 2010) to an estimate of between $2.92 and $3.05 per thousand, based on its 2010 budget but accounting for shifts that will occur once state valuations are updated.[4] The impact on a property in Highland Plantation that is assessed at $90,000 will be to reduce its property taxes from about $1,348 per year to between $262 and $275, a savings of nearly $1,100 per year.[5]
- Somerset County will see, on average, over the first several years the project is on line once state valuation is updated, an estimated increase of between $303,000 and $354,000 per year in the share of taxes paid by Highland Plantation,[6] reducing the county tax shares of other municipalities in Somerset County by a like amount.
- Municipalities around the state will have an additional estimated $11,000 in state aid to education[7] and an additional estimated $8,800 in municipal revenue sharing to share among themselves as a result of the redistribution of aid under these formulas.

Property tax calculations are presented in Appendix 21-2.

D. ***Community Benefits Package***: As mentioned earlier, under the Wind Energy Act a grid-scale wind energy development must provide at least $4,000 of community benefits, as defined in the law, for each turbine over 20 years. Highland Wind's project has 39 turbines. Therefore, at $4,000 per wind turbine per year for 20 years, the required value of its community benefits package is $3,120,000, or an average of $156,000 per year, above and beyond property tax payments resulting from the project. The community benefits package outlined below meets this requirement. Because Highland Wind is not using a tax increment financing approach that would have the effect of greatly reducing tax payments to the host community, LURC should be aware that Highland Plantation and its residents will be receiving very significant tax benefits, as set forth in Section C, above, in addition to the community benefits outlined below.

Highland Wind's community benefits package will include the following elements:

- **For Highland Plantation and its residents:**

  A. Highland Wind will provide to Highland Plantation and its residents twenty annual payments in the amount of $104,000 per year, with the initial annual payment from Highland Wind due the first date that ISO-New England verifies that Highland Wind is continuously delivering power into the grid (hereinafter "triggering date"). Over 20 years, Highland residents and the Plantation would receive $2,080,000 in total annual payments. In the alternative, and at the request of Highland Plantation, Highland Wind is prepared to make the entire 20-year value of these twenty payments available to Highland Plantation and its residents as a single, lump-sum payment due

[3] The local budget can vary dramatically from year to year, depending largely on the number of students of school age. Highland Wind's property taxes would vary accordingly.
[4] This assumes the 2010 budget holds steady. If the Plantation were to use the increased valuation to meet additional local needs or take on new expenses, the tax rate would vary accordingly.
[5] Due to the large amount of value added into a community with a very small population and budget, the impacts on individual taxpayers are very sensitive. Projections can fluctuate widely with changes in the assumptions on which the analysis is based, including, for example, assumptions about valuation method and assessed value ratio.
[6] Actual impacts on county taxes and state subsidies will vary based on a variety of factors, including, among other things, taxable value increases in other communities, state statutes governing education subsidies and revenue sharing, and other added taxable value in Highland Plantation.
[7] This amount can change from year to year based on the number of school-aged children in Highland Plantation.

at the triggering date, with the lump-sum amount calculated as a net present value of this twenty-year income stream.[8]

B. All payments owed to Highland Plantation and its residents would be distributed by Highland Wind to an agreed-upon third-party escrow/disbursal agent and placed in a segregated, separately invested and administered Highland Plantation Fund (HPF).C. Disbursements from the HPF will occur in the sequence set forth below. The first three categories of disbursement, consistent with 35-A MRSA §3451 (1-C) (B), will "reduce energy costs in the host community." The fourth category of disbursement will be made consistent with 35-A MRSA §3451 (1-C) (A), "payments, not including property tax payments, to the host community...".

▶ First, to reduce energy costs to the residents of Highland Plantation, annual payment directly to all existing Highland Plantation households as of January 1, 2011 (year-round and seasonal) for 20 years for day-to-day electrical use, as follows:

Each year-round and seasonal resident is entitled, no later than February 15 of the year following payment of electrical expenses for the preceding year, to submit an invoice with electrical bills to the agent for direct and immediate reimbursement from the HPF as follows:

-- Year-round residents would receive a lump sum payment equal to the value of 500 kilowatt-hours (KWh) per month of the energy generation portion of the price charged on Central Maine Power Company (CMP) bills to customers for the preceding May through November and 750 KWh per month of the energy generation price charged on CMP bills to customers for the preceding January through April and December; and

-- Seasonal residents would receive a lump sum payment equal to the cost actually incurred by those seasonal residents for their energy generation costs up to 500 KWh incurred per month for May-November.

-- The escrow/disbursal agent will verify qualifying expense, and disburse funds directly from HPF to the Highland Plantation household presenting the invoice. Because these benefits are tied to the residence, any subsequent owner of the residence is eligible for the remaining benefit.

▶ Second, to reduce energy costs to the residents of Highland Plantation and reduce their reliance on fossil fuel combustion, a one-time payment of up to $6,000 directly to all full-time residences as of January 1, 2011, in which the owner of the residence installs fossil fuel reduction measures for their homes, as follows:

-- Each full-time residence is entitled to receive a one-time grant of up to $6,000 for reimbursements from the HPF for expenses incurred for installation of home weatherization, solar heating or hot water, electrical thermal storage units and/or other fossil-fuel reduction measures. The grant can be for capital equipment and installation, including wiring and other costs to insure functionality of equipment. Grants are awarded for installations occurring in the first three full calendar years following occurrence of the triggering date, with the first calendar year counted as beginning on the next January 1 to occur following the triggering date. So long as installation is accomplished within these three calendar years, all installation expenditures does not have occur at one time; each full-time residence would have an account from which up to $6000 is available. Invoices for expenses incurred for previous year must be submitted to agent by February 15 of the year following expenditure, with all invoices submitted no later than by February 15 of year 4.

[8] By way of example only, if the net present value of $2,080,000 paid out over twenty years were to be calculated today using the applicable OMB discount rate, the lump-sum payment owed to Highland Plantation and its residents would equal $1,364,624.

-- The escrow/disbursal agent will verify qualifying expense, and disburse funds directly from HPF to the Highland Plantation household presenting the invoice. Because these benefits are tied to the residence, any subsequent owner of the residence is eligible for the remaining benefit.

▶ Third, to reduce energy costs to the residents of Highland Plantation and reduce their reliance on fossil fuel combustion, an annual payment for up to 20 years directly to all full-time residences who have installed thermo-heat storage units, as follows:

-- Each full-time residence that has installed in their home an electro-thermal heat storage unit (ETS) and a separate electrical meter that can measure and control off-peak power delivery, along with the wiring required to measure and direct electrical energy to that ETS, is entitled to receive a payment, on an annual basis, in an amount equal to the total monetary value of the difference, for the previous calendar year, between (1) the total off-peak KWh energy cost charged to the residence on its monthly CMP bill for the energy (not delivery) costs for off-peak energy used by the ETS, up to a total of 22,000 KWh of electricity, and (2) what the total off-peak KWh energy cost would have been had the residence been charged at a rate of $0.02 KWh for the same amount of energy.

For instance, should the actual energy rate charged by CMP for the year have been $0.05 KWh, then:

1. A qualifying residence that used 20,000 KWh of energy in that year for powering the ETS would be entitled to a monetary payment of $600 (20,000 KWh times $0.03); or

2. A qualifying residence that used 25,000 KWh of energy in that year for powering the ETS would be entitled to a monetary payment of $660 (capped limit of 22,000 KWh times $0.03).

-- The qualifying residence is responsible for the CMP delivery charges for this electricity.

-- No later than February 15 of the year following payment of electrical expenses for the ETS for the preceding year, the residence would submit an invoice to the agent with electrical bills showing the amount of the separate ETS metered electricity for the previous year, for direct and immediate reimbursement from the HPF. The escrow/disbursal agent will verify qualifying expense, and disburse funds directly from HPF to the Highland Plantation household presenting the invoice. Because these benefits are tied to the residence, any subsequent owner of the residence is eligible for the remaining benefit.

-- Regardless of when during the 20-year disbursement period a household first installed an ETS system and began receiving annual payments pursuant to this provision, all payments, and all obligations to make payments, shall cease following the final annual disbursement made in Year 21, as described below.

▶ Fourth, to assist Highland Plantation for other municipal costs that it incurs, all residual payments remaining after the above-discussed three reimbursements will be distributed to Highland Plantation, as follows. (The presentation that follows assumes that Highland Plantation chooses to receive annual payments of $104,000 and not a one-time lump-sum payment.)

-- On triggering event day, Highland Wind will deposit $208,000 (two annual payments of $104,000) into the HPF. The next annual payment of $104,000 (# 3 of 20) will be due on 3rd anniversary of triggering event, and annually thereafter until all 20 payments have been made.

-- On April 15 of Year 4, the assessors of Highland Plantation will receive from the escrow/disbursal agent all of what remains of the first three payments made by Highland Wind to the HPF, after all payouts for the first, second, and third direct disbursements to Highland Plantation residents, as stated above, have been made on or about February 15 of that year and all preceding years.

-- On April 15 of Year 5 and annually thereafter through Year 20, the assessors of Highland Plantation will receive the remainder of preceding year's annual payment, less all payouts to Highland Plantation residents made on or about February 15 of that year.

-- On April 15 in Year 21, all residual monies remaining in the HPF, plus accumulated interest, will be distributed in a lump-sum amount to the assessors of Highland Plantation.

- **For the Maine Department of Conservation, Bureau of Parks and Lands:** Highland Wind will provide $1,040,000 to the Maine Department of Conservation, Bureau of Parks and Lands (BPL) over a twenty year period, as a "donation for land or natural resource conservation" pursuant to 35-A MRSA §3451 (1-C) (C). This land or natural resource conservation will be comprised of two elements:

  A. Permanent protection for Stewart Mountain from the development of wind turbines. On or before the triggering date, Highland Wind shall execute or cause to be executed a legally sufficient document that will extinguish in perpetuity all rights of any current or future landowner to site wind turbines on the land comprising approximately 572 acres on Stewart Mountain that was previously proposed by Highland Wind as the location for eight wind turbines. The current fair market value lost for extinguishing these wind turbine development rights is $253,000.

  B. Payments for Additional Bigelow Preserve Viewshed Protection. Highland Wind will made twenty annual payments of $39,350 to BPL, to be used for protecting the viewshed from trails in the Bigelow Preserve. Over 20 years, BPL will receive $787,000 in total annual payments. The initial annual payment from Highland Wind is due on the triggering date. In the alternative, and at the request of BPL, Highland Wind is prepared to make the entire 20-year value of these twenty payments available to BPL as a single, lump-sum payment due at the triggering date, with the lump-sum amount calculated as a net present value of this twenty-year income stream.

  All payments owed to BPL would be distributed by Highland Wind to an agreed-upon third-party escrow/disbursal agent and placed in a segregated, separately invested and administered Bigelow Preserve Scenic Viewshed Fund. (Viewshed Fund). BPL will be granted the authority to use the monies in the Viewshed Fund to acquire in fee or easement properties that it deems to be valuable for protecting the viewshed from trails in the Bigelow Preserve. At BPL's choosing, a modest percentage of these funds (e.g., 10-20%) could be used for viewshed trail maintenance activities in the Preserve.

E. *Other Tangible Benefits*:

1. Reduction in air pollutants: An installed wind power capacity of 90 to 117 megawatts (MW) that produces 306,000 - 350,000 MW/hr/yr translates into an avoidance of a significant tonnage of green house gases each year that would otherwise be emitted by fossil fuel plants generating the same amount of electricity.
2. Energy price stability: Grid-scale wind projects typically enter into long-term supply contracts with electric power brokers. While usually there are escalators in the annual prices allowed for wind power in these contracts, the rate of inflation is relatively low. By comparison, prices for fossil fuels, including oil and natural gas, are projected to increase significantly over the next 25 years. According to the Energy Information Administration, the "reference" projection is for the price of oil to increase by 89 percent in real dollars by 2035 (after accounting for inflation), with a "high" projection showing an increase of 198 percent - nearly a tripling of prices. Natural gas prices are projected to double over this period of time.[9] If

[9] Energy Information Administration, "Annual Energy Outlook 2010 with Projections to 2035," viewed on the Internet at http://www.eia.gov/oiaf/aeo/index.html.

fossil fuel prices do rise as expected – and as of December 2010, the per barrel price of oil was following the "high" forecast projection – wind power capacity installed now will contribute to more stability in electricity prices in the future.

3. Wind-for-oil: Highland Wind aims to demonstrate at two different scales how wind power produced in Maine can reduce reliance on fossil fuels that are imported from out of state and allow for higher use of wind energy produced in Maine to the benefit of Maine customers. It will do so by providing direct assistance and incentives to use ETS units that can capture energy produced during off-peak hours and convert it to thermal energy for use during the day when demand for energy is high. Off-peak hours are those times of day or night when electric power is generally in surplus and therefore less expensive on wholesale exchanges. With the use of smart meters that control the time of day that energy is used, wind energy can be captured in the home or business during those off-peak hours for later use; thus it can both be a less expensive source of fuel and reduce dependence on fossil fuel combustion. Because institutional systems are not yet in place in Maine to price off-peak energy at low cost, Highland Wind will provide the means to do so on a demonstration basis.

    - At the residential scale, the community benefits package described earlier includes grants to residents of Highland Plantation to reduce reliance on fossil fuels. Residents may choose to use the grant for ETS units in their homes, and if they do, they will be entitled to a special reimbursement for off-peak use over 20 years, as described in Section D, Community Benefits Package, above, under the third category of disbursements from the proposed Highland Plantation Fund. This simulates an off-peak pricing system that can help drive use of wind power for heating.

    - At the institutional scale, Highland Wind and the University of Maine are entering into a Memorandum of Understanding, under which Highland Wind will provide ETS units that will be housed in a future expansion of the University of Maine's Offshore Wind Laboratory as a pilot project to demonstrate the efficient and effective use of wind generated power for space heating of buildings. The intent is not only to provide this indigenous, "green" source of space heating at the Laboratory, but also to (1) enable other interested members of the public to be able to visit and learn about the use of this technology, and (2) make the ETS units and their output available for data gathering and research purposes.

The monetary value of this tangible benefit to Highland Plantation residents who choose to install ETS units in their homes is discussed under community benefits. The capital value of the units to be placed at the University is $40,000. The potential benefit of demonstrating the viability of replacing fossil fuels for heating in Maine with renewable energy such as wind is much more far-reaching.

Appendix 21-1 – Tangible Benefits
The Economic Impacts of the Proposed Highland Wind Development in Highland Plantation, Somerset County, Maine

Prepared for:

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University of Southern Maine

December 2010

Introduction

Independence Wind Inc. proposes to build a 39 turbine wind power project in Highland Plantation, Somerset County. Independence Wind asked the Maine Center for Business and Economic Research (MCBER) at the University of Southern Maine to conduct an analysis of the impacts on the local, regional, and Maine economies. This report provides the results of that analysis.

To conduct the analysis, MCBER uses the econometric models developed by Regional Economic Models Inc. (REMI) of Amherst, MA and maintained by MCBER. These models are widely used to conduct this type of analysis, and have been used by MCBER to conduct several studies of wind power projects in Maine.

The models cover seven regions with Maine comprised of single or multiple county regions. For this analysis, the relevant regions for the project itself are:

Kennebec (Kennebec and Somerset Counties)

Western Maine (Androscoggin, Franklin, and Oxford Counties)

In addition, parts of the project planning and design work are done in Cumberland County and in Penobscot County (which is included in the Eastern region along with Piscataquis, Hancock, and Washington counties).

In the analysis, a base forecast of each of the regional economies is compared with an alternative forecast that includes the economic activity associated with the Independence Wind proposal. The differences between the two forecasts are the "impacts" of the project.

Input Assumptions

The following information reflects the inputs to the REMI model. These inputs were provided to MCBER by Independence Wind and are based on estimates of expenditures from other similar wind power projects constructed in Maine. The affected sectors are:

- Construction

  Construction expenditures are estimated at $48.95 million. This covers the costs of road, site preparation, and building construction plus installation of the towers and turbines. It excludes expenditures on the turbines and other electrical equipment that are not manufactured in Maine.

  The location of Highland Plantation at the border between Somerset and Franklin counties requires that some assumptions be made about the division of expenditures as these two counties lie in different regions within the REMI model. For this purpose the construction expenditures are assumed to be 65% in Somerset County and 35% in Franklin County.

  The project is assumed to begin construction in 2012 and to continue for 3 years. 10% of construction activity is assumed to be in 2012, 85% in 2013, and 5% in 2014.

- Equipment Rental & Leasing

  The construction of wind power projects is different than typical construction projects in that there are significant requirements for use of specialized equipment such as cranes and transporters. Expenditures for these types of equipment are not adequately represented in the industry average data used in the model, so an estimated $3 million is added to the Equipment and Rental & Leasing industry to reflect this aspect of wind power project construction.

  The expenditures for equipment rental may be made to the prime construction contractor or to firms specializing in this field. Equipment provided by prime contractors would normally be included in the construction industry expenditures. Discussions with Reed & Reed, the

construction company with the most experience building wind power projects in Maine, confirmed both the estimated amounts and the desirability of analyzing these expenditures as part of the equipment rental industry to reflect the particular circumstances of wind power construction.

Expenditures in this industry are assumed to be distributed across regions and the construction period in the same proportions as for the construction industry noted above.

- Accommodations and Food Services

  The construction of wind power projects in remote areas of Maine requires a combination of locally hired employees and employees with specific technical skills that are usually not available in the nearby area. Non-local employees will be housed in local hotels and will utilize local restaurants while they are working on the project.

  Total expenditures on food and accommodations are estimated at $400,000, distributed half between Franklin and Somerset counties, and to be distributed across the construction period in the same proportions as construction expenditures noted above.

- Professional and Technical Services

  The category “Professional and Technical Services” encompasses a variety of activities, including engineering, planning, meteorology, environmental analysis, and legal services. Total expenditures in this category are estimated at $7.9 million. These expenditures will primarily be made to firms outside of Somerset and Franklin counties.

  Engineering services ($900,000) include civil, geotechnical, architectural, and related services. These are assumed to be occur equally in 2011 and 2012 and to be made in Cumberland County (50%), Kennebec, and Penobscot counties (25% each).

Other permitting costs are estimated to occur in 2009, 2010, and 2011 (30% in 2009 and 2012 and 40% in 2011). Table 1 shows the assumed split among the regions for these years:

	2009	2010	2011
Cumberland	65%	65%	50%
Kennebec-Somerset	25%	25%	40%
Eastern Maine	10%	10%	10%

Table 1: Distribution of permitting costs by region

Table 2 on the following page shows the summary of inputs to the model by region, sector, and year.

		2009	2010	2011	2012	2013	2014	Total
Western Maine	Construction				1,713,250	14,562,625	856,625	17,132,500
	Equipment Leasing				105,000	892,500	52,500	1,050,000
	Accommodations				13,334	113,339	6,667	133,340
	Food				6,666	56,661	3,333	66,660
	Sub Total				*1,838,250*	*15,625,125*	*919,125*	18,382,500
Kennebec-Somerset	Construction				3,181,750	27,044,875	1,590,875	31,817,500
	Equipment Leasing				195,000	1,657,500	97,500	1,950,000
	Accommodations				13,334	113,339	6,667	133,340
	Food				6,666	56,661	3,333	66,660
	Prof & Tech	1,365,000	1,820,000	1,050,000				
	Sub Total	*1,365,000*	*1,820,000*	*1,050,000*	*3,396,750*	*28,872,375*	*1,698,375*	38,202,500
Cumberland	Prof & Tech	525,000	700,000	840,000				2,065,000
Eastern Maine	Prof & Tech	210,000	280,000	210,000				700,000
TOTAL		**2,100,000**	**2,800,000**	**2,100,000**	**5,235,000**	**44,497,500**	**2,617,500**	**59,350,000**

Table 2: In-state expenditures by region

RESULTS

Table 3 shows employment estimates in the Kennebec and Western regions based on the inputs described above, while Table 4 shows the personal income and wage & salary totals for each for the entire project period.

EMPLOYMENT	2009	2010	2011	2012	2013	2014
Kennebec-Western Regions	23	30	17	43	332	26
Rest of Maine	9	12	23	0	0	0
Total Maine	36	36	40	43	332	26

Table 3: Summary of construction period employment

	Personal Income	Wages & Salaries
Kennebec-Somerset	$11,490,000	$11,070,000
Androscoggin-Franklin-Oxford	$5,160,000	$4,640,000
Cumberland	$1,410,000	$620,000
Eastern	$2,040,000	$330,000
TOTAL	$20,100,000	$16,660,000

Table 4: Personal Income and Wages & Salaries 2009-2014 Totals

Major findings include:

- The project results in an average of about 100 jobs per year across the five years of project planning and construction, with residual employment continuing into a sixth year. During the peak year of construction, 2013, more than 330 jobs are created in the Franklin-Somerset regions and jobs will average about 36 jobs in the non-peak years.

- "Jobs" includes both direct jobs, which is employment directly engaged by the project developer and its contractors/subcontractors, and the indirect or "multiplier" employment. For this project, the multiplier is about 1.3, meaning that each direct job in the construction and professional-technical services industries supports .3 jobs in other industries.

- Because of the specialized nature of the construction project, most employees will come from outside the Franklin-Somerset region and will reside in the local area temporarily. However, most of the employees will come from within Maine.

- The communities of Bingham, Carrabassett Valley, Kingfield, Madison, and Skowhegan will receive most of the primary impacts from spending by employees during the construction period.

- Personal income in the Kennebec-Western Maine regions will increase by $16.6 million over the course of the project, of which $15.7 million will be in wages and salaries.[10]

- Statewide, personal income will increase by $20 million, of which $16.7 million is wages and salaries.

It should be noted that the jobs reported here are a combination of "new" jobs that would not exist but for this project and "supported" jobs, which already exist. Expenditures for the project provide revenues to various organizations that is translated into wages and salaries for these "supported jobs".

After the construction period is complete, about 8 employees will be required for operations of the wind power project. These employees will be located in a facility to be built in Highland Plantation. The majority of these employees will reside in Franklin and Somerset counties, although the exact distribution cannot be estimated at this time. These employees will spend money in the two counties, supporting jobs in the retail, service, and other industries.

During the operating period, it will be necessary to periodically undertake maintenance, including periodic replacement, on the towers and turbines. Because of the nature of wind power, these maintenance and replacement activities will resemble the construction period in terms of the number of workers required and the need to deploy equipment such as cranes. Neither the timing nor the extent of these activities can be accurately predicted at this time, but whenever they occur they will result in employment increases of 50-100 jobs, roughly distributed in the same industries as the construction period.

[10] In addition to wages and salaries, personal income includes "other labor payments" such as benefits and income to business proprietors.

Appendix 21-2 – Tangible Benefits
Property Tax Calculations

Highland Plantation
$247mm Project Cost
$197.6mm Additional Taxable Value

Mil Rate Projection: No Project

State Valuation 2010	**9,050,000**
Local Taxable Valuation 2010	**8,272,533**
Municipal Appropriations 2010	**198,371**
Municipal Tax Levy 2010	**123,923**
Mil Rate 2010	**14.98**

Calendar Year	Project Year	Municipal Valuation	Mil Rate
2010	Base	8,272,533	14.98
2011	1	8,272,533	14.98
2012	2	8,272,533	14.98
2013	3	8,272,533	14.98
2014	4	8,272,533	14.98
2015	5	8,272,533	14.98
2016	6	8,272,533	14.98
2017	7	8,272,533	14.98
2018	8	8,272,533	14.98
2019	9	8,272,533	14.98
2020	10	8,272,533	14.98

Highland Plantation
$247mm Project Cost
$197.60mm Additional Taxable Value

Projected Tax Impacts on $60k and $90K Parcels

		$60k Parcel			$90k Parcel			
Calendar Year	Project Year	Taxes w/out project	Taxes w/ project	Tax Savings w/ Project	Taxes w/out project	Taxes w/ project	Tax Savings w/ Project	% Tax Savings
2010	Base	$899	$899	$0	$1,348	$1,348	$0	
2011	1	$899	$899	$0	$1,348	$1,348	$0	
2012	2	$899	$36	$863	$1,348	$54	$1,294	95.98%
2013	3	$899	$37	$862	$1,348	$56	$1,292	95.86%
2014	4	$899	$38	$860	$1,348	$58	$1,291	95.73%
2015	5	$899	$175	$724	$1,348	$262	$1,086	80.54%
2016	6	$899	$170	$729	$1,348	$255	$1,093	81.08%
2017	7	$899	$172	$727	$1,348	$258	$1,091	80.90%
2018	8	$899	$173	$726	$1,348	$260	$1,088	80.72%
2019	9	$899	$175	$724	$1,348	$262	$1,086	80.53%
2020	10	$899	$177	$722	$1,348	$265	$1,083	80.34%
			total	$6,936		total	$10,404	
			average	$630.53		average	$945.80	

Highland Plantation
$247mm Project Cost
$197.6mm Additional Taxable Value

Projected Tax Shifts

	Calendar Year	Project Year	Education Aid Shift	County Tax Shift	Revenue Sharing Shift	Total Projected Revenue Losses
	2010	Base	0	0	0	0
	2011	1	0	0	0	0
in service	2012	2	$0	$0	$0	$0
	2013	3	$0	$0	$0	$0
	2014	4	$11,444	$403,587	$8,802	$423,832
	2015	5	$11,444	$372,496	$8,794	$392,734
	2016	6	$11,444	$361,677	$8,785	$381,906
	2017	7	$11,444	$351,162	$8,767	$371,373
	2018	8	$11,444	$340,943	$8,758	$361,144
	2019	9	$11,444	$331,012	$8,748	$351,204
	2020	10	$11,444	$321,362	$8,738	$341,545

Highland Plantation
$247mm Project Cost
$197.60mm Additional Taxable Value

Projected Mil Rate with New Project

	Calendar Year	Project Year	New Muni Valuation with project	New Budget With Offset for Tax Shifts	Projected Mil Rate $/1000	Company's Projected Taxes
	2010	Base	$8,272,533	$123,923	14.98006	$0
	2011	1	$8,272,533	$123,923	14.98006	$0
in service	2012	2	$205,872,533	$123,923	0.60194	$118,943
	2013	3	$199,696,357	$123,923	0.62056	$118,943
	2014	4	$193,705,466	$123,923	0.63975	$118,943
	2015	5	$187,894,302	$547,755	2.91523	$525,699
	2016	6	$182,257,473	$516,657	2.83476	$495,850
	2017	7	$176,789,749	$505,829	2.86119	$485,455
	2018	8	$171,486,057	$495,305	2.88831	$475,353
	2019	9	$166,341,475	$485,077	2.91615	$465,534
	2020	10	$161,351,231	$475,137	2.94474	$455,992

Assumptions:

1. The in service/construction complete date will be on or before 4/1/2012.
2. 80% of Project Costs will be recognized as tangible taxable property.
3. The Plantation's budget will remain relatively constant except for increases to make up for projected tax shifts due to project.
4. The State Valuation process used for county taxes, school funding and state revenue sharing typically takes two years to capture new value.
5. The community's school budget appropriations will remain relatively constant.
6. The cost approach to valuation currently in use for valuing commercial wind generation facilities by Maine Revenue Services (MRS) recognizes annual depreciation. Based on MRS methods applied to date, commercial wind generation facilities have an expected service life of 20 years, which correlates to a %5 rate of depreciation each year. The model uses a more conservative depreciation rate of 3% per year. It is expected that the valuation of commercial wind generation facilities will, within the next five years, also include an income approach to valuation similar to the method of valuation for hydro electric facilities, with the result that the assessed value will eventually stabilize over the balance of the facility's operating life.
7. These projections are based on the most current state revenue sharing projections, the most current county budget and education funding information, and the assumption that there will continue to be available revenues to fund schools and provide revenue sharing distributions. Changes in the valuation of sister county communities, rankings for state valuation purposes and changes in local appropriations will have marked and potentially dramatic impacts on these projections.

Highland Plantation

$210mm Project Cost

$168mm Additional Taxable Value

Mil Rate Projection: No Project

State Valuation 2010	9,050,000
Local Taxable Valuation 2010	8,272,533
Municipal Appropriations 2010	198,371
Municipal Tax Levy 2010	123,923
Mil Rate 2010	14.98

Calendar Year	Project Year	Municipal Valuation	Mil Rate
2010	Base	8,272,533	14.98
2011	1	8,272,533	14.98
2012	2	8,272,533	14.98
2013	3	8,272,533	14.98
2014	4	8,272,533	14.98
2015	5	8,272,533	14.98
2016	6	8,272,533	14.98
2017	7	8,272,533	14.98
2018	8	8,272,533	14.98
2019	9	8,272,533	14.98
2020	10	8,272,533	14.98

Highland Plantation

$210mm Project Cost

$168mm Additional Taxable Value

Projected Tax Impacts on $60k and $90K Parcels

		$60k Parcel			$90k Parcel			
Calendar Year	Project Year	Taxes w/out project	Taxes w/ project	Tax Savings w/ Project	Taxes w/out project	Taxes w/ project	Tax Savings w/ Project	% Tax Savings
2010	Base	$899	$899	$0	$1,348	$1,348	$0	
2011	1	$899	$899	$0	$1,348	$1,348	$0	
2012	2	$899	$42	$857	$1,348	$63	$1,285	95.31%
2013	3	$899	$43	$855	$1,348	$65	$1,283	95.16%
2014	4	$899	$45	$854	$1,348	$67	$1,281	95.01%
2015	5	$899	$183	$715	$1,348	$275	$1,073	79.59%
2016	6	$899	$178	$721	$1,348	$267	$1,082	80.22%
2017	7	$899	$180	$719	$1,348	$269	$1,079	80.02%
2018	8	$899	$181	$717	$1,348	$272	$1,076	79.81%
2019	9	$899	$183	$715	$1,348	$275	$1,073	79.60%
2020	10	$899	$185	$713	$1,348	$278	$1,070	79.38%
			total	$6,868		total	$10,302	
			average	$624.34		average	$936.51	

Highland Plantation

$210mm Project Cost

$168mm Additional Taxable Value

Projected Tax Shifts

	Calendar Year	Project Year	Education Aid Shift	County Tax Shift	Revenue Sharing Shift	Total Projected Revenue Losses
	$2,010	Base	$0	$0	$0	$0
	$2,011	$1	$0	$0	$0	$0
in service	$2,012	$2	$0	$0	$0	$0
	$2,013	$3	$0	$0	$0	$0
	$2,014	$4	$11,444	$347,777	$8,755	$367,975
	$2,015	$5	$11,444	$318,259	$8,745	$338,448
	$2,016	$6	$11,444	$308,971	$8,735	$329,150
	$2,017	$7	$11,444	$299,946	$8,725	$320,115
	$2,018	$8	$11,444	$291,178	$8,714	$311,336
	$2,019	$9	$11,444	$282,660	$8,703	$302,807
	$2,020	$10	$11,444	$274,385	$8,692	$294,520

Highland Plantation

$210mm Project Cost

$168mm Additional Taxable Value

Projected Mil Rate with New Project

	Calendar Year	Project Year	New Muni Valuation with project	New Budget With Offset for Tax Shifts	Projected Mil Rate $/1000	Company's Projected Taxes
	2010	Base	$8,272,533	$123,923	14.98006	$0
	2011	1	$8,272,533	$123,923	14.98006	$0
in service	2012	2	$176,272,533	$123,923	0.70302	$118,107
	2013	3	$170,984,357	$123,923	0.72476	$118,107
	2014	4	$165,854,826	$123,923	0.74718	$118,107
	2015	5	$160,879,182	$491,898	3.05756	$468,813
	2016	6	$156,052,806	$462,371	2.96291	$440,672
	2017	7	$151,371,222	$453,073	2.99312	$431,810
	2018	8	$146,830,085	$444,038	3.02416	$423,199
	2019	9	$142,425,183	$435,259	3.05605	$414,832
	2020	10	$138,152,427	$426,730	3.08883	$406,703

Assumptions:

1 The in service/construction complete date will be on or before 4/1/2012.

2 80% of Project Costs will be recognized as tangible taxable property.

3 The Plantation's budget will remain relatively constant except for increases to make up for projected tax shifts due to project.

4 The State Valuation process used for county taxes, school funding and state revenue sharing typically takes two years to capture new value.

5 The community's school budget appropriations will remain relatively constant.

6 The cost approach to valuation currently in use for valuing commercial wind generation facilities by Maine Revenue Services (MRS) recognizes annual depreciation. Based on MRS methods applied to date, commercial wind generation facilities have an expected service life of 20 years, which correlates to a %5 rate of depreciation each year. The model uses a more conservative depreciation rate of 3% per year. It is expected that the valuation of commercial wind generation facilities will, within the next five years, also include an income approach to valuation similar to the method of valuation for hydro electric facilities, with the result that the assessed value will eventually stabilize over the balance of the facility's operating life.

7 These projections are based on the most current state revenue sharing projections, the most current county budget and education funding information, and the assumption that there will continue to be available revenues to fund schools and provide revenue sharing distributions. Changes in the valuation of sister county communities, rankings for state valuation purposes and changes in local appropriations will have marked and potentially dramatic impacts on these projections.