Final Report to the Heath Planning Board on Siting of Industrial-Scale Wind Turbines in Heath

Heath Renewable Energy Advisory Committee

Global Warming and Climate Change: The Committee at the outset of its proceeding acknowledged the science of climate change and the necessity to transition to non-fossil fuel energy sources. These sources include solar, wind, geothermal, hydro, wave, tidal, biological and, potentially, fusion. Notwithstanding the societal need to move away from fossil fuel, the Committee could not assume at the start of its deliberations that every alternative energy source was equally available in all locations or equally benign in its impact. Since the Committee was charged with researching utility scale wind in Heath, it began its research with an assessment of the availability of wind in our region as a resource for the industrial production of electricity.

1. Wind Resource Availability: The National Renewable Energy Lab (NREL), a branch of the US Department of Energy, ranks the wind resource availability in all 50 States. It defines the amount of a wind resource in terms of the nameplate gigawatts of electricity potentially installable. It assumes a capacity factor of 30% at 80 meters above ground level.

To clarify the technical terms: “nameplate” refers to the *maximum* output of electricity if the wind were to blow consistently, 24/7, 52 weeks per year at some ideal speed specified for wind turbines. Because of the unpredictable variability of wind speeds, the maximum is never reached. The *actual* output reflects this variability of speed, and is defined as a *percentage* of the maximum output. The percentage is referred to as the “capacity factor”. Multiplying the nameplate capacity of a wind turbine by the capacity factor gives the actual output of the turbine. The NREL considers that a capacity factor of 30% to be the minimum needed for the commercial viability of a wind development.

The data from the NREL show that the region of the United States with the strongest wind energy potential *for land based wind turbines* lies exclusively in the Midwest, from Texas to the Dakotas. Texas, for example has a wind potential of about 1901 gigawatts, Iowa, 570 gigawatts. By comparison Massachusetts has a nameplate wind potential of one gigawatt. With a wind potential of 1/10,000 of that of the country, it ranks 35th amongst the other states. The Committee then analyzed what percent of Massachusetts's electricity consumption could be met by the one gigawatt of nameplate capacity potentially installable in the State. Using a capacity factor of 30%, the actual output to be expected from land based turbines would be about 0.3 gigawatts. The US DOE shows that the State consumes about 6 gigawatts on average. Dividing the expected 0.3 gigawatts of actual output by the 6 gigawatts needed, the greatest contribution which land-based wind turbines can make to meet the State's electricity needs is about 5%. In assuming a 30% capacity factor, the Committee has given the benefit the doubt to the wind industry. In analyzing the capacity factors of surrounding states, New York State had an average capacity factor in 2010 of 22.7%; Searsburg, VT during the first 10 years of its operation 20.9%; and Maine 23.69% for the first three quarters of this year. The same analysis done over the eastern third of the country shows the land-based wind potential to be a negligible resource for generating electricity.

The Committee then focused on the wind resource available in western Massachusetts and Heath in particular. The NREL maps shows wind speeds on average of about 14.3 to 15.7 MPH at 50 meters above ground in Heath. The NREL data show that the best wind potential in western Massachusetts is equal to the worst wind resource in states such as Texas and Iowa. The original maps categorized such speeds as poor to marginal for industrial wind production. However, the Patrick Administration, once it adopted its wind agenda, appears to have reclassified those speeds as fair to good without any demonstrable scientific rational.

Any claim that industrial wind could do for Heath what Yankee Atomic did for Rowe is built on illusion. To put into perspective the electricity potential from wind in Heath, the Committee compared the output of Yankee Atomic in Rowe with the expected output of industrial wind in Heath. The Yankee atomic facility had a nameplate capacity of 181 megawatts and a capacity factor of 74% over its 36-year lifecycle--the actual output averaged 136 MW. If Heath were to permit an industrial wind complex the size of the 19-turbine Hoosac facility in Monroe and Florida, each turbine would have a nameplate capacity of 1.5 MW. The total nameplate capacity would be 28.5 MW. Using a 30% capacity factor, the expected output would be 8.5 in Heath as compared to 136 MW at Yankee Atomic in Rowe.

Our estimate for Heath is overly optimistic. Our analysis was based on the Hoosac facility, which is located on an average 2,300-foot elevation. The highest peak in Heath is 1,900 feet. Our analysis also used a 30% capacity factor, which we have shown has not been met in either New York, Vermont or Maine. In order to match the output of Yankee Atomic in Heath using wind, the Town would need over 300 wind turbines, each the size of a 40-story skyscraper (400 ft tall). Given the setbacks, with just three turbine sites, Heath would essentially need to be depopulated.

2. Carbon Dioxide Reduction: Because the wind resource in western Massachusetts is so limited, the CO_2 reduction to be expected from land based wind turbines is negligible. The Committee followed the analysis of Ben Luce, a physicist and chairperson of the Sustainable Energy Department at Lyndon State College in Vermont. The 5% reduction of fossil fuel-generated electricity, alluded to above, was analyzed for its impact on reducing CO_2 emissions. The State publishes data on the contribution of each sector of the economy to CO_2 emissions. Electric generation contributes 28.68 % to the total CO_2 load in the State. Therefore, the 5% reduction of fossil fueled generation can be expected to reduce CO_2 emissions by 28.68 % of 5%, or 1.43%.

The Committee then used another stream of data from Hoosac to verify this order of magnitude measure. Iberdrola the developer of Hoosac, estimated that the Hoosac facility would reduce CO_2 emissions in the State by about 100,000,000 pounds annually (or 45,359 metric tons). The State data show the State emits 84,830,000 metric tons of CO_2 annually. Dividing 45,359 metric tons by 84,830,000 metric tons, Hoosac would enable 0.05 % reduction in the CO_2 emission of the State annually. But, Hoosac is just one facility. How many Hoosacs could be installed? Using the NREL data showing about one gigawatt (1000 MW) of nameplate potential in the State, approximately 36 Hoosac sized facilities could be built. (1000 divided by 28.5). If each facility reduced CO_2 emissions by 0.05%, then 36 such facilities would reduce CO_2 emission by 36 times 0.05 or 1.8%. This is very strong agreement with our previous estimate using a different data stream.

This analysis is exclusively a wind resource limitation argument. It has nothing to do with the intermittency argument. The intermittency line of reason shows a marked inefficiency in the combustion of fossil fuel caused by the ramping up and down of the fossil fueled backup with the variability of wind speeds. There are studies in the literature which show that the wind resource limitation AND the inefficiencies in integrating wind-generated electricity into the grid, actually increase the consumption of fossil fuel used and CO_2 emissions into the atmosphere. Again, the Committee wanted to be as liberal as possible in our assessment of the benefits to be provided by wind. *Our conclusion: There is no significant amount of electricity to be produced or CO_2 emissions to be reduced by land-based, industrial-scale wind development in Massachusetts and in Heath in particular.*

3. Wind Turbine Noise and Health Impacts: The Committee reviewed the research on the effects of wind turbine noise on human health. By way of introduction: sound is a vibrational disturbance to the atmosphere which assumes the form of a wave. There are two characteristics of waves whose effects we examined separately and then together. 1) The amplitude of the wave which is the intensity of the disturbance to the atmosphere, usually represented by the height of the wave. The maxim height we label a wave peak; 2) the frequency of the wave, which is represented as the number of wave peaks which pass through a point in space. Frequency is related to the wavelength, which is the distance between successive wave peaks. The shorter the wavelength, the higher is the frequency. (As an analogy, the shorter the distance between cars traveling on a highway, the greater the number of cars will pass a given point on the highway). The height of a wave is subjectively experienced as loudness, and is measured in decibels (dB). The frequency of a wave is subjectively experienced as pitch (*e.g.*, C, D, E, F, G). We considered the sound emissions from industrial wind turbines along these two parameters, loudness and pitch.

We first consider the effects of wave intensity (i.e. loudness). Loudness diminishes as a function of distance: the greater the distance the lesser the loudness, a pretty obvious assertion. But, can we quantify the relationship of distance to loudness in such a way as to roughly determine the distance needed to lower noise to acceptable levels? The answer is complicated by: 1) what we mean by "acceptable", 2) the frequency of the sound emitted, 3) the atmospheric conditions under which the sound is emitted, e.g. wind sheer, humidity, topography, etc., and finally, 4) the noise "signature" of the source. (All noise is *not* the same).

With regard to acceptability, there is no absolute standard. Extensive literature shows that adverse community responses to noise is a function of the increase of noise over the ambient noise level prior to the introduction of the new noise source. The International Standards Organization (ISO) has established standards for noise which we looked at for solar. They show that at 5 dB above ambient, noise complaints are scattered, at 10 dB noise complaints are widespread, and at 15 dB, complaints are severe. Following Kampermann and James, we used the 5 dB above ambient in our solar by-law to obviate widespread negative community reactions. The State uses 10 dB above ambient, but it is important to note that even the State uses a ***relational*** standard and ***not*** any ***absolute*** limit. So, ignoring the other three complicating factors listed above, the question is: What is the minimum distance of a wind turbine so that the noise emitted from it does not exceed 5 dB above ambient at the nearest residence or property line?

We really don't have to guess at an answer. There is an extensive empirical literature on ambient sound levels in rural environments relating distance to noise attenuation. Graphs provided by Robert Rand Associates show the results of testing the ambient noise level throughout rural New England. Twenty to twenty-five dB seems to be the average outcome. For example, Ashfield tested at 26 dB last March in a professional sound study. Using the 5 dB above ambient as a standard, and assuming a 20-25 dB preconstruction noise level, we would want to require no more than 25 to 30 dB at any property line or residence in Heath, (subject of course to results of actual measurements of ambient noise at a chosen site). So, how far from a residence would a turbine have to be to comply with that standard?

Three studies in Maine are relevant here: Vinalhaven, Mars Hills, and Freedom. Each shows how noise decays as a function of distance. Essentially, they show that more than 5,000 feet (nearly one mile) is needed to reduce turbine noise levels to 25 to 30 dB level at the nearest residence. At one half mile, the noise level is between 40 and 48 dB, well above the noise level we currently experience in Heath, and exceeding even the State noise limit by 10 to 18 dB above ambient. Considering that decibels are log functions, this increase of noise level would totally transform the soundscape of our community, approaching suburban and even some urban values. These studies were conducted in relatively windless conditions at the ground level, and with only moderate wind speeds aloft. At higher values of surface wind speeds, the distance needed from turbine to receptor site would have to be considerably increased to accomplish the same noise attenuation. Also, note that these sound studies were done only for relatively high frequency waves (2,000 to 20,000 cycles per second or Hz, the so-called A-weighted spectrum), not ***low*** frequency waves such as emitted by wind turbines.

A study by Pederson *et al.* shows that ***low*** frequency waves (20 to 250 Hz) decay at half the rate of high frequency waves. The low frequency study was not done at the above sites. But extrapolating from their A weighted values, it is not unreasonable to assume that if a mile is required to attenuate high frequency waves to acceptable values, then two miles would be required to attenuate low frequency waves. Pederson shows that the high frequency component of the acoustic signature increases as the size and power output of wind turbines increase. In order to boost power output, modern turbine technology increases height in order to capture the faster wind speeds at higher elevations. Therefore, one might expect the trend of the technology to increase the low frequency issues.

The human reaction to noise is not simply a function of loudness. The response to wind turbine noise is reported as much more adverse than the response to other industrial noises ***at the same decibel level***. As indicated above, the decibel level measures only the perceived loudness of sound. But, there is a lot more to sound than its loudness, just as loudness is not sufficient to characterize human speech and music. Therefore, it is reasonable to consider these other parameters of sound in assessing wind turbine noise. People complain of a peculiar and particularly debilitating quality to the sound from turbines. A paper by Thorne in the journal, "Bulletin of Science and Technology" August 2011, shows that unlike other industrial noises, the amplitude and frequency of wind turbine noise is continuously modulated (AM and FM). That is, the pitch and the loudness *are not steady but change continuously*. Another example of AM and FM modulation is the sound of a police cruiser or fire truck. The continuous change of pitch and loudness makes it very hard for people to become desensitized or habituated to the sound, as occurs with other industrial sounds. On the contrary, sensitization over time appears to occur more frequently when pitch and loudness are modulated. Also, as wave frequency decreases, the effectiveness of barriers such as walls and windows to attenuate sound is diminished. Windows and walls are actually induced to vibrate at lower frequencies. Decreasing wave frequency is the same as increasing wavelength. As the wavelength approaches the dimensions of rooms and houses, standing waves are set up within these structures. As the waves bounce back and forth in these enclosed spaces their amplitude (loudness) increases, much as the height of a child on a swing increases each time it is given a push. They become resonant chambers in their own right, resulting in indoor noise levels *higher* than those outdoors.

Finally, as wave frequency decreases to 1 to 20 Hz (compared to the 2,000 to 20,000 Hz of high frequency waves) low level biological effects occur: tinnitus, vestibular disorders, rapid heart beat (tachycardia). In addition to the inner ear, other organs of the body are affected, cardio vascular, skeleton-muscular (bone conduction of low level vibrations). Very few industrial sources of noise reach the low frequencies that wind turbines do.

Adverse reactions to wind turbine noise have been documented in numerous peer reviewed studies. The Committee has reviewed more than a hundred such studies, including those of Pederson in Europe, Nissenbaum in Maine, Hanning & Evans in England, Krogh in Ontario, Canada, Ambrose and Rand in Falmouth, Massachusetts, Cooper in Australia. The constellation of symptoms is the same across the globe and across all cultures: Sleep disruption, stress, anxiety, migraine, the full spectrum of inner ear disorders, ringing, vertigo, motion sickness and balance issues. The verbalizations of the complaints are eerily the same: "The sound of a freight train", "the sound of a circling jet plane coming in all directions but never stopping."

There is a well respected methodology for determining the level of subjective stress to any external disturbance. It involves examining what people *do* in open and public ways to alleviate their inner state of *health*. In effect, people *externalize their subjective* feelings of illness by their *actions*. The public avenue of redress for wind turbine symptoms includes letters to the editors of local papers, petitions to Boards of Health, law suits, and in final desperation, ***abandonment*** of their homes. When a group of residents near a wind complex spends hundreds of thousands of dollar to engage an attorney to relieve the noise of a wind turbine, their complaints are real and compelling. The Committee looked at dozens of letters from aggrieved Massachusetts residents, including those from Fairhaven, Falmouth, Kingston, Scituate, Newburyport, Hyannis, Nantucket, Hancock in Berkshire County near Brody Mountain, and Lowell VT. There is hardly a single wind turbine in the Eastern part of the State which hasn't stimulated widespread community complaints. And most of these are solitaire wind turbines. The only exception to widespread complaint we could find is Hull, Massachusetts, which is located on a direct flight path to Logan International Airport. Otherwise the complaints extend across the State. For example, in less than nine months of operation, the Scituate, MA Board of Health is being petitioned to either shut down the Town's single 1.5 MW wind turbine, or curtail its night time operation. The Committee has also reviewed lawsuits against wind developers in Templeton, MA, Vinalhaven, Freedom and Mars Hills, Maine, and Herkimer County, New York. And we have hardly exhausted the list.

Finally, the Committee studied some complicating factors affecting noise propagation. As shown earlier, a two mile separation of a wind turbine from the nearest property line would be needed to safeguard against high frequency *and* low frequency noise. The empirical data from Maine on sound decay pointed in this direction. But those studies were done on relatively windless days at the surface. Ambient wind speed and direction affect the distance which noise travels as does relative humidity. A denser (water-filled) atmosphere increases the amplitude (the loudness) of acoustic waves and the distance they travel. Topography also complicates the picture. Echo affects from hills and valleys and intercepting vegetation make it virtually impossible to reliably predict the pathway of noise. Homes at a thousand feet distance may be unaffected by noise on a particular day with the wind blowing from a particular direction but a home five miles away may be severely impacted. Robert Rand (in a private communication) indicated that two mile setbacks in hilly terrain may not be sufficient protection. In early November, scores of residents three and a half miles and more from the Lowell VT wind complex jointly petitioned the State Department of Public Service about the deafening sound emitted from the complex.

Wind sheer further complicates the picture. Wind speed is not a simple linear function of elevation. At night, the wind speed may be close to zero near the surface of the earth. But, above 100 feet, wind speed may suddenly increase over a short distance. This is wind sheer. The higher wind speeds aloft may rotate the blades of the turbine and produce the characteristic turbine noise. At the same time, the calm wind condition at the surface below would not have the characteristic noise of wind to mask the noise emitted by the turbine. This is in contrast to the claims of the wind turbine industry. In fact, wind sheer is the prevalent wind pattern at night in interior New England. For all these reasons (unpredictable variations of wind speed and direction at ground level, humidity, topography and wind sheer), the intensity of turbine noise is typically underestimated by developers.

The health affects of industrial wind are not limited to those resulting from acoustic waves. The Committee briefly considered the effect of seismic vibrations on nearby structures. A moderate size industrial turbine of 1.5 MW weighs about 160 tons, with seven ton blades rotating at close to 180 MPH at the periphery. When it is installed on ledge, massive blasting or other alteration of the ridge top may be required to anchor it to the ground. The coupling of the turbine to ledge propagates the vibrations of the structure, generated by the torques of the rotating blades, to the ground beneath. Any residential structure in the path of the seismic waves would be exposed to vibration. A home near the relatively small wind turbine in Charlemont is subject to internal vibration from the basement up whenever the turbine rotates. The vibration has been likened to the ground vibration induced by a device farmers use to eject burrowing animals from their subterranean abodes.

Vibration, whether acoustic or seismic, does not exhaust the health affects of wind turbines. However idyllic they appear from a distance, wind turbines are industrial structures. A typical wind turbine contains hundreds of gallons of oil and other fluids; a wind farm, thousands of gallons. Lubricants and coolants are contained not only in the blade structure and nacelle of the body, but also in the massive electric transformers required in the complex. The potential for ground water contamination from fluid leaks can not be underestimated in assessing the suitability of this technology for Heath. Indeed, the Lowell Mountain project in Vermont had a significant oil leak last fall.

Finally in assessing the health impact of possible industrial wind in Heath, the Committee was not unmindful of the State DPH report on industrial wind. Essentially, the report exonerated the industry of any significant health impacts. In an effort to achieve objectivity in our work, members of the Committee studied the Report. Our critique of the report, briefly stated, is as follows:

A. While the Report was offered as a literature review, the report failed to consider in its conclusions any reference to the ongoing complaints of severe health reactions to turbine noise made by the residents of our State (*e.g.*, in Falmouth and Fairhaven). Indeed, the DPH staff which authored the report failed to address or follow up on any complaints made by citizens living in its backyard. Instead they relied almost exclusively on four studies in Sweden and the Netherlands while ignoring the evidence in cities and towns nearby;

B. Of the hundreds of citations contained in the report, most implicated industrial wind in producing health issues for residents living within miles of turbine sites. The Report ignored the results of almost all of the studies they referenced and instead relied on only the four from the aforementioned countries;

C. The Report justified its exclusion of studies which were at variance with its conclusions by advocating for a methodology for assessing causation which it claimed the other studies lacked. First, it used a direct theory of causation. "A" can be said to cause "B" only if it is "*unmediated*." And so they ignored the Nissenbaum study in Maine on sleep deprivation. The report conceded that the noise emissions from turbines may be correlated with sleep deprivation, and that sleep deprivation may be correlated with illness, but it is only the *direct* correlation which can be construed as causal. That is, it is sleep disturbance which causes illness and not turbine noise emission. Evidently there is no transitivity in their theory of causation. More generally, in their simplistic model of causation, if "A" can be construed as causing "B", the biological organism is not supposed to participate in the production of symptoms. On the premise of this methodology, if a virus is correlated with illness in some people but not in others, the virus is not the cause of illnesses because differences in biology mediate its effects. Causation is direct, never mediated, on the premises of the Report.

Second, the Study used a single factor theory of causation. Thus, if "A" is correlated with "C" only in the presence of "B", then "A" can not be construed as a cause of "C". And so, since the Swedish studies show that wind turbine noise was correlated with adverse reactions only with visual access to the turbine, according to the DPH conclusions, the turbine noise can not be construed as the cause of the adverse reaction. That vision interacts with sound in the perception of noise is a well established psychoacoustic finding. But, that there is an interaction between the two does not preclude that each is a casual *factor* in the reaction. Rarely in complex systems do factors have effects independent of other factors. The Study used the same line of reasoning to discount turbine noise as a cause of illness because the effect was correlated with negative attitudes about the technology.

D. The Report eschewed studies with small sample sizes. While the Committee recognizes the necessity for further research over larger populations, there is the danger that large scale studies over-aggregate data. A large scale study with course-grained categories has the potential to conceal patterns which would otherwise be revealed by finer grained analysis.

For example, the definition of “rural” in the Swedish studies was too general. The study attempted to show the affects of the rural character of the environment on the reaction to turbine noise emissions. But their criterion of “rural” encompassed too many differences among communities. In our own area, for example, Heath, Whatley and Bernadston are rural. But, there are major difference in the ambient noise level of these three towns which would affect the masking of wind turbine noise, and hence resident's reactions to that noise. The "averaging out" which dilutes these differences would make predictions of response to turbine noise in a particular rural environment highly unreliable.

E. Finally, the Report denied the potential of very low frequency acoustical waves (infrasound) to impair human health. Infrasound is barely audible and mostly inaudible. The premise of the report is that if an acoustical wave does not get represented as sound by the human ear, it can do no harm. This position has no merit, as may be seen by analogy with electromagnetic waves. The visual senses of biological organisms are sensitive to a very narrow range of the electromagnetic spectrum. In particular the eye cannot detect the higher frequency ultraviolet waves above the color violet or the lower frequency infrared waves below the color red. But, that the biological eye can not respond to waves outside its spectral sensitivity does not mean that these waves can not affect other organs of the body. Anyone who has experienced a sunburn from ultraviolet waves (which cannot be seen) knows otherwise. The State Report failed to give any cogent critique to the work of Alec Salt on the affect of infrasound on the vestibular system or other organs of the body involved in balance or motion.

Space doesn't permit further analysis of the State DPH Report. In general, the Committee concluded that the State DPH Report appears only intended to bend the science to conform to policy. As such, it belongs in the same category as the industry funded research which denied the ill-health affects of DDT, tobacco, asbestos, and the effects of fossil fuel on climate change. The Committee encourages peer-reviewed research without a policy agenda.

4. Safe Distance Setbacks: The noise coming from wind turbines is primarily aerodynamic in character. The rotating blades perturb the atmosphere and generate vortices over their surfaces. The disturbances get propagated as waves which travel miles until they are dampened down. If the turbine could be structurally encased to intercept the traveling waves, the noise emissions would be limited within short distances. But, of course, any structural encasement of a turbine would deprive it of the wind which is its source of energy. Therefore, the only way to reduce the noise and health affects is to interpolate distance between the turbine and the Receiver. How much distance? Our study of noise suggested one mile for high frequency noise and two miles for low frequency noise. These distances are consistent with the growing consensus that setbacks should be on the order of one and a quarter miles in flat terrain and two miles in hilly terrain. These are minimum distances. The work of Kamperman and James, the Ecology Institute, and Carmen Krogh all point in this direction.

The Committee is not unaware that current setbacks are on the order of feet and not miles. But current setbacks have mostly been designed to advance policy agendas and not human health. The wind industry has set setbacks as multiples of blade length in order to maximize turbine placements per unit area. States, awash in federal money to promote industrial wind, have the same agenda. The Committee expects Massachusetts to recommend 2,500 feet as the standard setback. But, as our research on noise has shown, a setback of 2,500 feet would yield noise levels of about 45 dB, 20 dB more than our ambient level and 15 dB above the State's own noise standard. If the goal is to protect human health and the quality of our lives in Heath, then one to two mile setback should be implemented.

The Committee spent much time analyzing the geographic distribution of our population. We agreed that setbacks should be between the closest turbine and the nearest property line. If setbacks were established between the turbine site and the nearest occupied residence, then property closer to the turbine than the occupied residence would fall inside the setback area and thus become very limited for any development. This could amount to a land-taking and be highly prejudicial to the affected land owner. The Committee carefully examined the property lines of the Town. It quickly determined that all our property lines are closer than one mile to the site of any possible turbine purposed for the Town. *Our population is too uniformly distributed through the Town and our parcels of land too small to achieve the setbacks needed to protect our citizens from the health affects of Industrial-Scale Wind Turbines*. This conclusion weighed heavily in determining our final recommendations to the Planning Board.

5. Property Value Impacts: The Committee considered the impact of industrial wind on property values to be an important part of our work. Home equity is the biggest asset of middle class Americans. We took seriously any impact which would substantially reduce the real estate equity of our citizens.

The Committee reviewed over 20 property value impact studies. All except two reported substantial reduction in propriety values as a function of distance to the turbine site. The two which departed from the consensus were not done by professional real estate appraisers, but graduate students, funded by a wind lobbying group in one case and a government agency with a wind agenda on the other. The general consensus of the studies was a 25% to 40 % reduction of property values within a two mile radius of the wind turbine site. The variance in the studies is explained by 1) the population density of the affected community -- the more rural the area, the greater the impact) and, 2) distance to the turbine site --the closer to the turbine site, the greater the impact. The two studies which were an exception to the consensus aggregated the data so as to conceal the relationship of distance and rural character to valuation impacts. The Committee settled on the Clarkson study to assess the valuation impacts of wind in Heath because it distinguished between impacts in rural and suburban environments, and because the distance metric in that study was far more fine-grained than those of the two aberrant studies (Hinman and Hoen); Clarkson used a tenth of a mile metric. The deep bias in the Hoen study is evidenced by the fact that he excluded abandoned homes, fire sales to wind developers, and selling prices too far below the mean from the grouped data of the study. He also ignored days-on-market as a marker for valuation impact.

The Committee assessed the aggregate reduction in property value within an area scribed by a two mile radius of a wind turbine. It chose a wind turbine location such that the area of its impact had to fall exclusively within the borders of the Town. An ideal location meeting this criterion was the top of Bray Road. Its area of impact is exclusively within the Town boundaries; it has access to two sets of transmission lines, and is at one of the Heath's highest elevations. A two mile radius would generate an impact area of 12.56 square miles. The total area of the Town is

24.9 square miles. Dividing the former by the latter, 50.44% of the Town would be within the impact area of a single wind turbine.

Because the Committee did not have the time to determine the value of each property within the impact area, it worked with aggregate data from the FY 2013 Town Budget. According to the Budget, the Town's total assessed valuation is $87,644,392. Assuming homogeneity of property distribution, 50.44% of that valuation, or $44,207,831 would lie inside the impact area. The Committee then needed to determine by what percent that assessed valuation would drop. It chose the Clarkson study which showed a median percentage drop of property values in rural environments of 25%. A 25% reduction of $44,207,831in assessed valuation would amount to $11,051,958. *Stated otherwise, the Town would be expected to incur an aggregate drop of $11,051,958 in assessed valuation within a 2 mile radius of an Industrial-Scale Wind Turbine*. Since there are 292 housing units in Heath (the 2000 year census), 50.44% of them, or 147, would lie in the impact area (again assuming homogeneity). *The total property devaluation would therefore equate to $75,183 per household on average in the affected area ($*11,051,958 *divided by 147).*

6. Tax Revenue Impact. The projected drop in property value has enormous tax implications. The FY2013 has a projected tax rate of $20.07 per thousand. A $11,051,958 drop in property value would therefore generate a $221,813 loss of tax revenue to the Town, unless offset in other ways ($11,051,958 divided by 1,000 times $20.07). There are two ways this loss might be offset. Raising the tax rate is one approach. Those households inside and outside the impact area would be affected differently. Those inside the area would see their tax rates increase which would be offset by the decline in their property assessments. Their tax assessments would probably not change. Those outside the impact area would not see their assessed valuations decline, so that the higher tax rates would increase their tax assessments. This scenario is not without precedent. The City of Fairhaven is projected to lose 27% of its tax base, as 90% of its population lives within two miles of the two wind turbines there. The effect on Heath would be less severe because of our lower population density, but not without major challenges to recovering the lost revenue.

A second response to the potential loss of tax revenue is the collection of "Payments in Lieu of Taxes" (PILOT). The Committee has attempted to research the potential of this revenue source. It is clear that a one- or two-turbine complex would yield no revenue to the Town, unless the Town owned the complex. The experience of Princeton, MA should be a warning to any town contemplating a move in that direction. Turbine mechanical failure together with a 25% lower output than expected and extraordinary maintenance costs has generated a cumulative debt to the Town of $1.875 million since 2009. The underperformance of the turbines has resulted in electricity rates to its citizens which are the highest in the State.

As for PILOT payment from a privately held turbine farm, the nine-turbine Monroe complex might net that Town about $122,000 ($13,500 per turbine) annually. The average compensation seems to be from $13,000 to $14,000 in other agreements the Committee has examined, but these are proposed agreements. There is no history in the State as yet of agreements that have been implemented. If the Town were to approve a 16-turbine installation, the expected revenue input would just about offset the loss in tax revenue resulting from the property devaluation (16 times $13,500 = $216,000).

And so, at best, industrial wind in Heath would be revenue neutral (best case scenario with pilot payments from a sixteen-turbine complex) or revenue negative (worse case scenario with a single turbine installation). The Committee notes one caveat in its analysis. It assumed that the impact area is the same for both a single-turbine and a sixteen-turbine complex. But, if a sixteen turbine complex were to enlarge the impact area beyond that of one or two turbines, the resulting loss in tax revenues, due to an expanded range of property value reduction, would most likely exceed the income from such a complex. Revenue neutrality would then not be achieved even for a 16-turbine complex. Since impact area is not a simple linear function of number of turbines; the Committee assumed the impact area to be constant in order to maximize our assessment of revenue benefits from industrial wind to the Town.

7. **Other Impacts.** The Committee studied a number of other impacts which it briefly summarizes as follows. Construction and transport of industrial sized wind turbines would require massive tree cutting and widening of public roads up to eighty feet. Many narrow by-ways bracketed by historic stone walls would be irreparably disturbed. The Town would have to incur the expense of maintaining public ways bearing much heavier loads for continuous repair and maintenance of these structures. There is substantial evidence that satellite communications and relay stations are impaired by the electric field set up by turbine generators. Shadow flicker when the blades intercept the sun at certain times of the day is a risk to those subject to epileptic seizures. Ice throws, blade failure, fire from lightning hits, soil erosion from ridge road construction, and the health impairment to domestic farm animals are all additional concerns that must be addressed. Finally, there is the impact on species of animals other than our own. Apart from habitat fragmentation caused by forest clear cutting for turbine installation, animals lower on the evolutionary scale depend on sound to adapt to the environment. The intrusion of low frequency and infrasound into their habitat will foul the signaling systems of most animals, forcing their emigration from the region. The setbacks we might set for ourselves would be of no avail to the animals which inhabit our forest lands and meadows. As conservators of nature, it would be of profound negligence to undermine the habitat of our animal populations, in the name of protecting the environment.

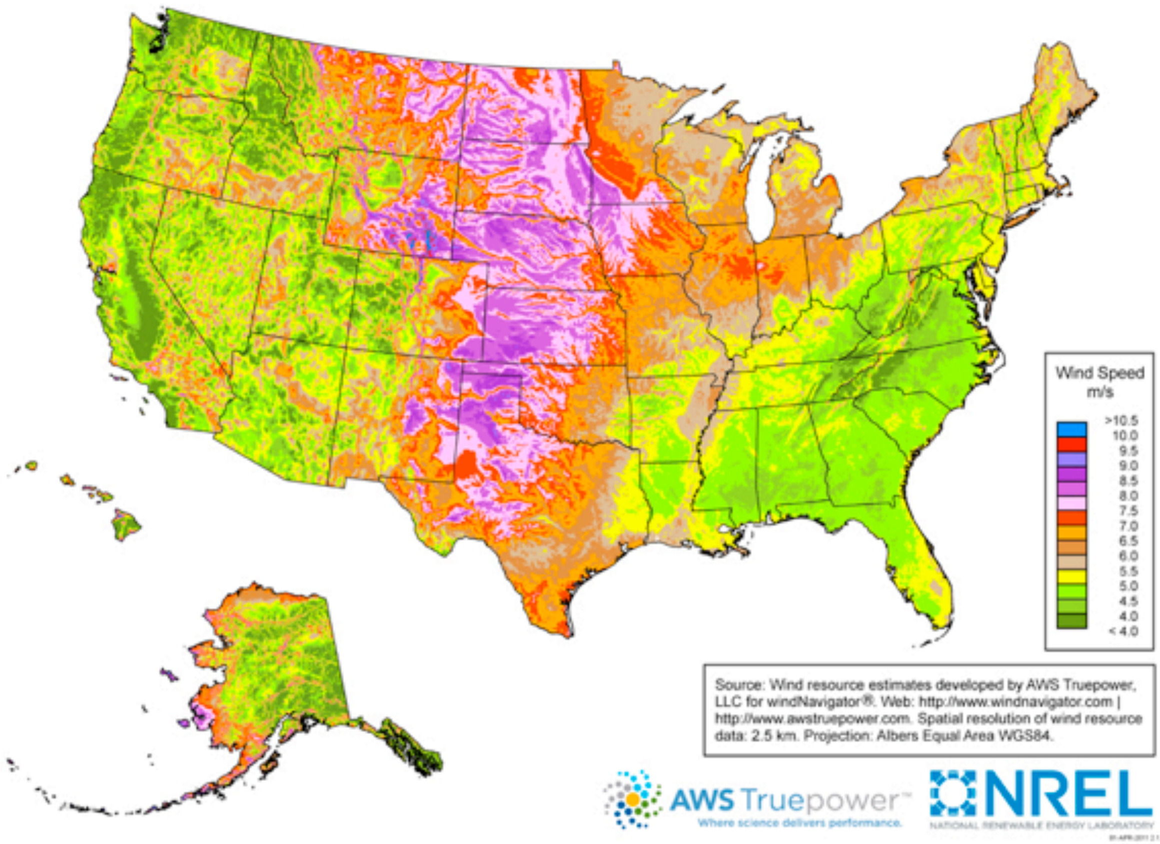
Conclusions and Recommendation. Throughout its deliberations the Committee has operated as though it were doing a cost-benefit analysis. We began our research on industrial wind right at the start with an evaluation of the potential of industrial wind to ameliorate CO_2 emissions and their disastrous impact on the earth's climate. Had we discovered a strong positive contribution, then the benefit might have outweighed the cost. If there were indeed a major reduction of CO_2 emission to be had by industrializing our Town with wind turbines, then we might have argued that the costs to human health and the quality of our lives might have had to be endured for the higher good. After conducting extensive research, we see no such benefit. At best we see the potential for about a 1.5 % reduction of CO_2 emissions. Not mentioned in the text above is the lack of any benefit in terms of reducing the national demand for foreign oil. The generation of electricity uses less than 1% of oil from any source. From a more parochial standpoint, our research suggested no substantial net revenue gains to the Town. At best, industrial wind in the Town would be revenue neutral, on the most optimistic assessment.

If the benefit side of the ledger is zero, what of the cost side? In the absence of any viable setbacks, we saw profound changes to the soundscape of our community. Noise levels approaching urban values would become the rule. But noise elevation doesn't really do justice to the impact of industrial wind. Noise sounds like nuisance. And most noise can be tolerated if we put our minds to it. But, if we understand the nature of the source, we will understand that noise in the trivial sense of nuisance is not the issue. Commercial wind turbines are huge open air industrial machines, the size of urban skyscrapers. They shake, they rattle, they creek, they perturb the ground below, and they are illuminated at night with flashing lights. Their 7 ton blades whirl at tornado-like tangential speeds emitting volleys of acoustical energy into the atmosphere for miles around. However graceful they may appear over the horizon from a distance, their reality on the ground close-by is quite otherwise. If they were emitting chemical pollution they would be an object of scorn. But apparently their emission of massive quantities of acoustical energy saturating and fouling the auditory and vestibular systems of humans and animals alike goes unnoticed by their proponents. On balance, the Committee sees no benefit to offset these costs. Therefore it sees no reason to promote or enable the siting of industrial wind in our Town.

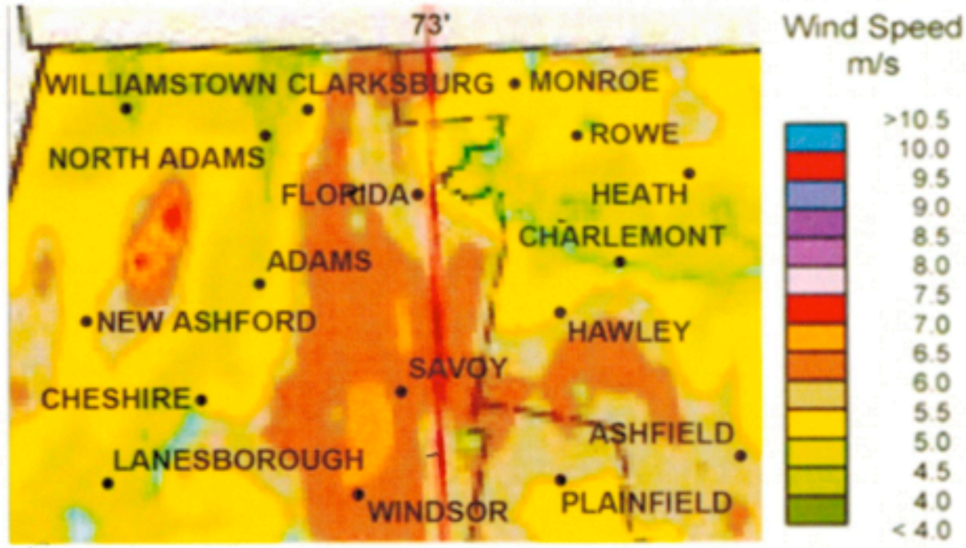
Our recommendations to the Planning Board reflect this cost-benefit analysis. If it were possible to reduce the cost in terms of noise and health by implementing one or two mile setbacks, then the costs might not have exceeded the benefit: zero cost and zero benefit. Under such a scenario it might have recommended a set of regulatory by-laws providing for height and setback limitations. But, setbacks of these magnitudes cannot be realized in our Town. All of the occupied dwellings and property lines in Heath are less than a mile from ANY potential location of an Industrial-Scale Wind Turbine. The Committee has determined that mandating setbacks in a regulatory by-law which cannot be realized is not only disingenuous, but would render the town vulnerable to litigation by an aggressive developer intent on industrializing Heath with wind turbines. The only reasonable alternative to a regulatory by law is a ban. The Attorney General has already set the precedent for approving a ban in Shelburne. The Committee sees no reason why approval would not be forthcoming for Heath.

The committee suggests that a ban on industrial wind be incorporated in a revision of the current by-law on wind. The by-law would be generalized to cover all scales of wind: large scale and small scale. Small scale on-site residential systems with maximum 100 foot heights and 10 KW output limitations would be permitted. Any off-premise use of any size would not be allowed. The ban could be incorporated in the land-use tables of our zoning districts. The Committee would also recommend adjustment to the noise limits and the setbacks of the small scale systems in the light of the data it has discovered for the large scale variants. A ban as we have described would be a relatively simple document to write. The Shelburne ban approved by the AG was a few sentences.

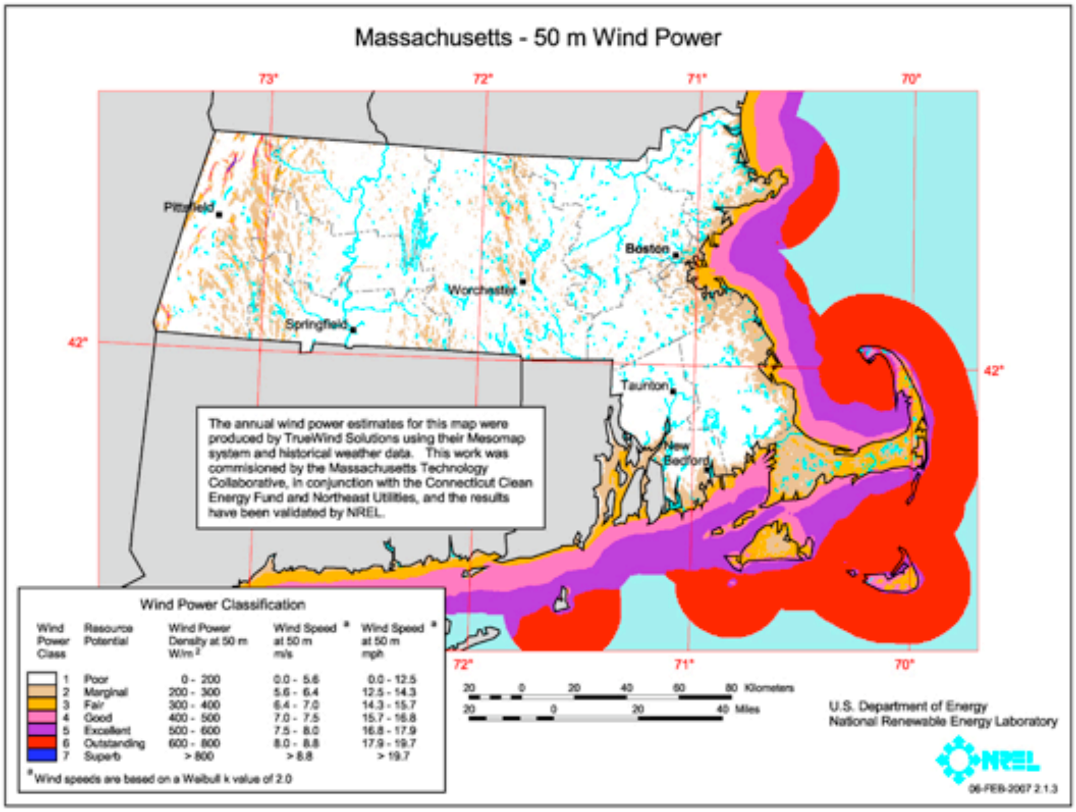
Finally, the Committee would like to thank the Planning Board for the encouragement it has given us in our deliberations. We look forward to further collaboration with the PB until our commission expires.


Wind Speed
m/s
>10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
< 4.0
Source: Wind resource estimates developed by AWS Truepower, LLC for windNavigator®. Web: http://www.windnavigator.com | http://www.awstruepower.com. Spatial resolution of wind resource data: 2.5 km. Projection: Albers Equal Area WGS84.
AWS Truepower™
Where science delivers performance.
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

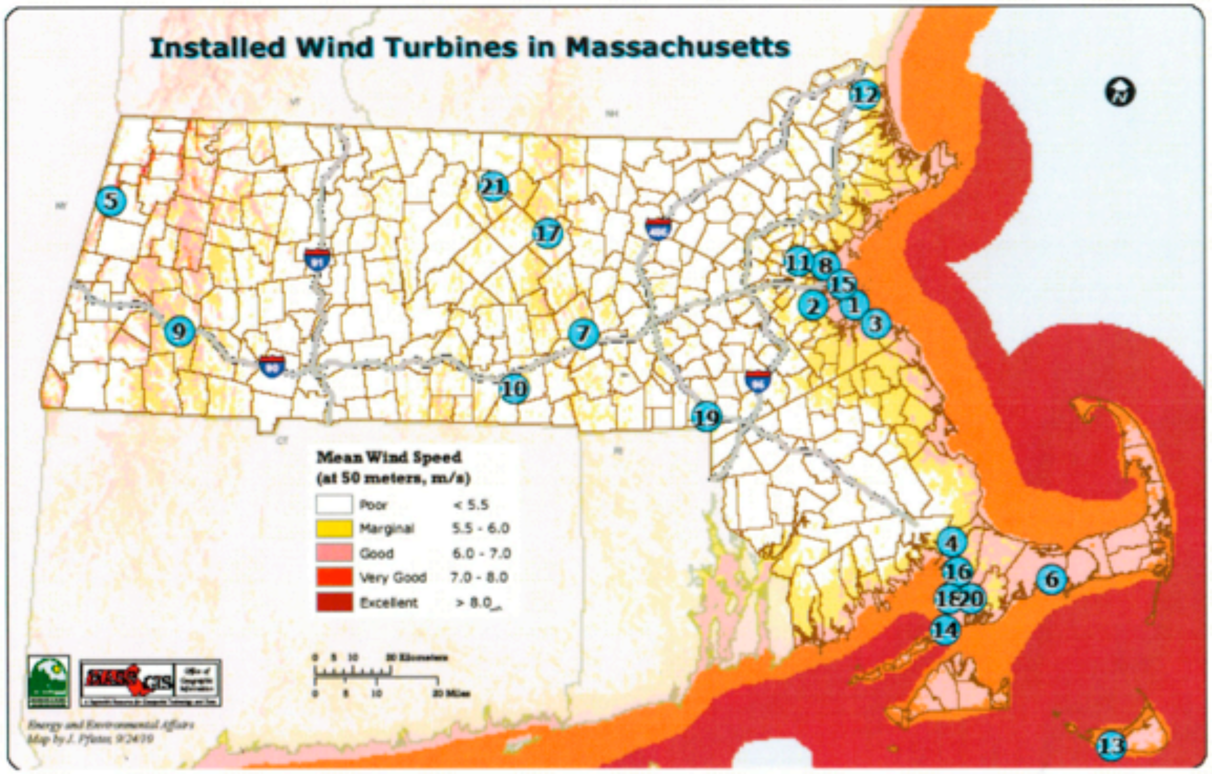
Average annual wind speed at 80 meters: Northwestern Massachusetts



Source: National Renewable Energy Lab


Massachusetts - 50 m Wind Power
73°
72°
71°
70°
42°
Pittsfield
Boston
Worchester
Springfield
Taunton
New Bedford
The annual wind power estimates for this map were produced by TrueWind Solutions using their Mesomap system and historical weather data. This work was commisioned by the Massachusetts Technology Collaborative, in conjunction with the Connecticut Clean Energy Fund and Northeast Utilities, and the results have been validated by NREL.
Wind Power Classification
Wind Power Class | Resource Potential | Wind Power Density at 50 m W/m2 | Wind Speed* at 50 m m/s | Wind Speed* at 50 m mph
1 Poor 0 - 200 0.0 - 5.6 0.0 - 12.5
2 Marginal 200 - 300 5.6 - 6.4 12.5 - 14.3
3 Fair 300 - 400 6.4 - 7.0 14.3 - 15.7
4 Good 400 - 500 7.0 - 7.5 15.7 - 16.8
5 Excellent 500 - 600 7.5 - 8.0 16.8 - 17.9
6 Outstanding 600 - 800 8.0 - 8.8 17.9 - 19.7
7 Superb > 800 > 8.8 > 19.7
*Wind speeds are based on a Weibull k value of 2.0
Kilometers
Miles
U.S. Department of Energy
National Renewable Energy Laboratory
06-FEB-2007 2.1.3

Massachusetts Installed Projects



Executive Office of Energy and Environmental Affairs

Cost/Benefit Analysis of Industrial Wind Facilities: A Model

**Model does not include non-quantitative issues such as health, adverse affects on town values, etc.*

Town Budget FY2013

Expenses			**Revenues**		
Article 3		$1,131,669	Offsets:		
Warrant Articles		$869,525	Cherry Sheet		$89,293
Subtotal=	$2,001,194		Estimated Receipts		$126,461
			Free Cash Offset		$50,000
Assessor's Overlay		$26,235	Assessor's Overlay Surplus		$3,211
State Charges		$503			
			Subtotal=	$268,965	
			Tax Levy		$1,758,967
			Est. FY13 rate of	$20.07	
			Total Assessed Valuation	$87,644,392	
Total		**$2,027,932**	**Total**		**$2,027,932**
Facility related added expenses			Negative tax revenues from reduced property values * [see calc below]		-$221,805
X					
Y			Potential tax revenues from Facilities		
Z			16 turbines @ $13,500		$216,000
Subtotal =					
Adjusted Total Expenses		$2,027,932	**Adjusted Total Revenues**		$2,022,127
			Variance		-$5,805

*		
tax Levy		$1,758,967
houses affected	50.44 %	$887,223
25% loss		$665,417
net revenue loss		$221,806