Report of the Wind Advisory Committee to the Shelburne Falls Planning Board

Date: October 7, 2013

Introduction and Overview

The Wind Advisory Committee (WAC) has taken as its point of departure the Zoning Bylaw, proposed and voted on in May 2012,[1] regarding Premises Use Wind Turbine Systems. The Bylaw appears as § 2.39 and reads as follows:

"2.39: Wind Turbine Systems for Premises Use:

> Any system of turbines, whether located on the building or the ground, designed primarily to generate heat or electricity for the principal home or business located on the lot; such systems may generate a limited amount of excess electricity for resale to an electrical utility provided the system is designed principally to supply the electrical needs of the home or business on the lot."

As written, the bylaw requires more detailed and specific interpretations for the Special Permitting Authority (now the Zoning Board of Appeals) to review, accept, or reject specific proposals for premises-use only wind turbine systems.

The WAC has been tasked by the PB to develop factual and educational material upon which it can draw when developing a more detailed premises use only bylaw. This Report summarizes that factual and educational material. When useful, the Report cites and paraphrases scientific research articles, research reported on web sites, investigations made by committee members and anecdotal evidence. Where useful, the Report makes recommendations to the PB, based upon the information that it has gathered and analyzed.

[1] The Bylaw appeared as Article 18 (Petition Article) to the warrants voted on at the May 2012 Annual Town Meeting.

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Part I. Operational and Technical Matters

Section 1: Technology – Models, availability, and price

Wind turbines generate electricity by physically spinning a coil of wire through a magnetic field. The force that drives the spinning comes from wind. The spinning can happen on a horizontal axis or a vertical axis. In Horizontal Axis Wind Turbines (HAWTs) the blades are perpendicular to the ground. This is the kind of turbine we are most familiar with. The blades need to face into the direction of the wind to operate well. In Vertical Axis Wind Turbines (VAWTs) the blades are like a paddleboat or eggbeater. The turbine operation is independent of wind direction.

Turbines can generate DC or AC power. Some generate DC and have inverters built into the machine so that they can connect to the power grid. DC units are intended for off-the-grid applications and are used to charge batteries. Most of the units we focused on generate AC power and are intended to be hooked up to the grid so that excess power can be sold.

The American Wind Energy Association (AWEA) reports that there are 54 small turbine models available for sale in the United States and more than 150,000 have been installed.

Since 2010, the Small Wind Certification Council (SWCC) has certified turbines to the standards outlined by the AWEA. It is advertised as an independent body, but the three commissioners appointed to do the certifications are all "industry experts."[2] One of the commissioners is the founder and president of a private firm that designs and builds small wind turbines. However, the Council appears to have a sound reputation. New York State Energy Research and Development Authority (NYSERDA) does require all turbines installed in NY be SWCC certified. Massachusetts requires certification from NYSERDA or the SWCC.

As of August 31, 2013, SWCC had certified seven small wind turbines. All of the units have rate power outputs <10kW. The units certified are:

- Bergey Excel 10
- Bergey Excel 6
- Endurance S-343
- Evance R9000
- Kestrel e400nb (by Eveready Diversified Products, Ltd)
- Kingspan Renewables Ltd KW6
- Southwest Windpower Skystream 3.7

There are fourteen other models that have certifications in process and two of these have temporary certification:

[2] http://www.smallwindcertification.org/about/who-we-are/commisioners/

- Eoltec's Scirocco E5.6-6
- Gaia Wind Ltd GW133-11kw

Of all these models, the Bergey is made in America and is available at numerous locations. Sirius Inc. in Shutesbury is one of four authorized dealers in Massachusetts. Bergey posts a price list online. The Excel 6 is no longer being made. The Excel 5 seems to have replaced it. This is a 5kW model.

- Bergey Excel 5 = $21,995
- Bergey Excel 10 = $31,770

Southwest Skystream 3.7 is available at various locations in the USA. Its full power output is 1.8kW.[3] A search on the web showed that the price depends on the size of the tower.

- Skystream 3.7 on 45 foot tower = $9700
- Skystream 3.7 on 60 foot tower = $13,000

Kingspan, Evance and Endurance are British makes and prices are not available on the web.

Section 2: Small wind definition and efficiency studies

The Massachusetts Clean Energy Center defines micro wind as turbines with rated power outputs from 1kW to 99kW (http://www.masscec.com/solicitations/commonwealth-wind-small-wind). It uses the words "micro wind" and "small wind" interchangeably. The micro wind initiative applies to residential, commercial, or public uses. The American Wind Energy Association, an industry group, defines small wind as turbines with capacity < 100kW.

A study by the Cadmus Group of small wind turbines (turbines with rated power output < 10kW) in Massachusetts found that installed units were producing, on average less than one-third of their expected power outputs (Cadmus 2008). The reasons for this are not understood. It could be that wind resources in Massachusetts are overestimated or that the performance capacity of the machines is over-rated. A similar study of micro wind turbines in the United Kingdom (http://doc.wind-watch.org/AEA-UK-Small-Wind-Survey-2008.pdf) reached a very similar conclusion: actual generation was far below the expected power levels. These studies challenge calculated estimates of the amount of installed wind power production statewide. It is unlikely that wind turbines installed in Shelburne will generate power at anything near to their rated capacity.

Section 3: Setbacks & height of wind turbines

The height of a wind turbine is defined as the maximum distance from the ground of any element of the turbine. For Horizontal Axis Wind Turbines this is usually the tip of the blade.

[3] http://www.txspc.com/PDF/skystrea_%203.7t.pdf

Since the blades are mounted at the top of the tower, the tower is not the tallest part of the machine.

The integrity of wind turbine blades is important for the operation of the turbine and the safety of life and property nearby. While blades are tested upon manufacture, aging and fatigue or stress from lightning, ice, and bird strikes can happen. Wind turbine blades can also accumulate ice under some conditions. This ice builds up and then can be thrown from a spinning turbine, with considerable force. To protect public safety and the integrity of property, setbacks are commonly required. We have found that most communities have setbacks for wind turbines from lot lines and structures ranging from equal to height of turbine up to twice the height.

Section 4: Anticipated size of premises-use wind turbine systems

Clearly, the power generation capacities of premises-use turbines should be determined by the power needs at the premises. In an attempt to determine the varying load patterns of residences, light industry, commercial space and farms, we tried to get billing data from WMECO. They refused to provide such data. We turned to secondary sources and based upon our analysis, discussed below, we conclude that ***the ranges*** of turbine capacities for premises-use are the following:

- Residential → 2.5 – 5 kW for the average home; 10 kW for the largest homes.
- Agricultural → 10 – 25 kW
- Commercial → 5-10 kW per 1,000 ft^2 of commercial space. For a commercial establishment with 2-3 times that footprint, one would multiply the capacity by 2-3. Food-related entities require greater capacity, which can be calculated using Table 2.
- Light industry →7.5-10 kW.

These ranges translate into the following ***maximum*** kW capacity limits for premises use. These limits should allow for the loads for the preponderance of applicants in Shelburne Falls.

- Residential – ***10 kW***
- Agricultural – ***25 kW***
- Commercial – ***30 kW*** for the largest spaces (3,000 ft^2).
- Light industry – ***10 kW***.

Discussion and Analysis

- **Residential Load**

Based upon survey estimates of average monthly residential consumption in New England, overall and by state (Table 1 below), ***average daily energy consumption*** is about 21 kWh, with a high of 24.3 kWh (CT) and a low of 17.1 kWh (ME). For Shelburne, the survey estimates for Maine and Vermont are likely most accurate: 17.1-18.8 kWh, since Shelburne Falls likely resembles these rural states more than it does the Eastern part of the Commonwealth. The average daily energy consumption for all of Massachusetts (which represents to a great degree usage patterns in Eastern Massachusetts) is approximately 21.1 kWh.

How large a turbine is needed to generate 17 – 19 kWh a day? To answer this we assume:

1. the premises–use wind turbine system is sized to average daily consumption (hence average annual load);
2. net metering allows the residence to adjust as demand varies from the average (above and below);
3. wind does not blow all the time. The "system capacity factor" indicates what percentage of the time the windmill is actually generating electricity. We suggest three scenarios for capacity factors.

Daily Load	Capacity Factor	System Capacity
17-19 kWh	30%	2.4-2.7 kW
17-19 kWh	20%	3.5-4.0 kW
17-19 kWh	15%	4.7-5.3 kW

We conclude that the size of premises-use wind turbines would range from 2.5-5 kW, depending upon the capacity factors (CFs) of the system of turbines.

Of course, the more electricity consumed on premises, the larger would be the power of the wind system needed. We believe it unlikely that a purely residential system would require more than twice the capacity of the average home. Hence, we recommend that the maximum allowable residential turbine system be 10 kW. If an applicant were to demonstrate that her/his electrical load was greater than twice the average, she/he could file to the ZBA for a special permit to install a system > 10 kW. The ZBA would review the applicant energy usage patterns and determine whether a somewhat larger premises-use system is to be allowed.

- **Agricultural residence and outbuildings**

Based upon the residential numbers, we approximate that a farm residence and outbuildings likely would require 10 kW, perhaps 15 kW of capacity. The EIA (DOE Energy Information Agency) does not provide estimates of electricity consumption by farms (that we could find). We have been informed by John Wheeler that his solar installation has a capacity of 10 kW, and that he could consider increasing that somewhat. He informed us of a second farm, the Manning farm, which has solar arrays with 19 kW of capacity. To accommodate the possibility of somewhat larger usage, we recommend setting the maximum size at 25 kW.

- **Commercial Load**

The energy consumption of commercial establishments is usually measured ***per sq. ft. of space, per year***. Table 2 provides estimates of energy consumption per sq. ft. per year ***by type of commercial establishment***, based upon a 1995 survey, which was the most recent we could find in a usable format. More recent information indicates that commercial consumption has increased, on average.[4] The ***average*** energy consumption over all commercial space in 1995 was ***13.4 kWh per ft.^{2}*** per year, which is greater than the consumption by educational facilities and retail/service entities (***around 10 kWh/sq. ft.***) and less than consumption by office space (***nearly 20 kWh/sq. ft.***). Electrical consumption by food service or food sales entities is much greater than all other commercial users by 2-4 times. If food service or sales entity were to apply for a permit to install a premises-use turbine system, that entity could present its electrical use to the ZBA for approval.

If we take the two estimates cited above (educational and retail space (< 10 kWh/ft^2/yr) and office space (<20 kWh/ft^2/yr)) as lower and upper bounds, appropriate ***for most*** commercial space in Shelburne, and assume a 1,000 sq. ft. footprint for the commercial entity, the annual load is 10,000 – 20,000 kWh/year; or 27 – 55 kWh per day. The implied capacities required for commercial premises-use wind, under the same assumptions for sizing residential premises are:

Daily Load	Capacity Factor	System Capacity
27-55 kWh	30%	3.75 – 7.6 kW
27-55 kWh	20%	5.6 – 11.5 kW

For most commercial establishments, turbine capacity would likely range from 5 – 10 kW per 1,000 ft^2. If CFs are poor, one might need capacity of 15 kW per 1,000 ft^2; however, as noted above, we have found no evidence suggesting that the smaller turbines have such low CFs. These capacity sizes can be ***increased per ft^2***. For example, if the largest footprint were 3,000 ft^2, the required range of capacities would be 15-30 kW for CFs of 20%. The CFs will be provided by the manufacturer; however, all evidence we have reviewed suggests that manufacturers overstate the CFs of their equipment. Likewise, if food services or food sales establishment would come before the Special Permitting Authority (SPA), it could use these same data and analytic steps to size the equipment for premises use. Likewise, if we needed to approximate increased usage per ft^2 using the overall increases presented in footnote 4, the SPA could do so using the information in footnote 4.

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[4] The most recent information we have found ***projects*** average commercial usage per ft^2 in 2005 to range from 14 to 16 kWh per ft^2; see http://www.pnl.gov/main/publications/external/technical_reports/PNNL-16820.pdf, Figure 1.2. Relative to the average over all sectors in 1995 (13.4 kWh per ft^2), this represents an increase of 4 to 19%. It is unclear how usages by specific type of commercial establishment have changed.

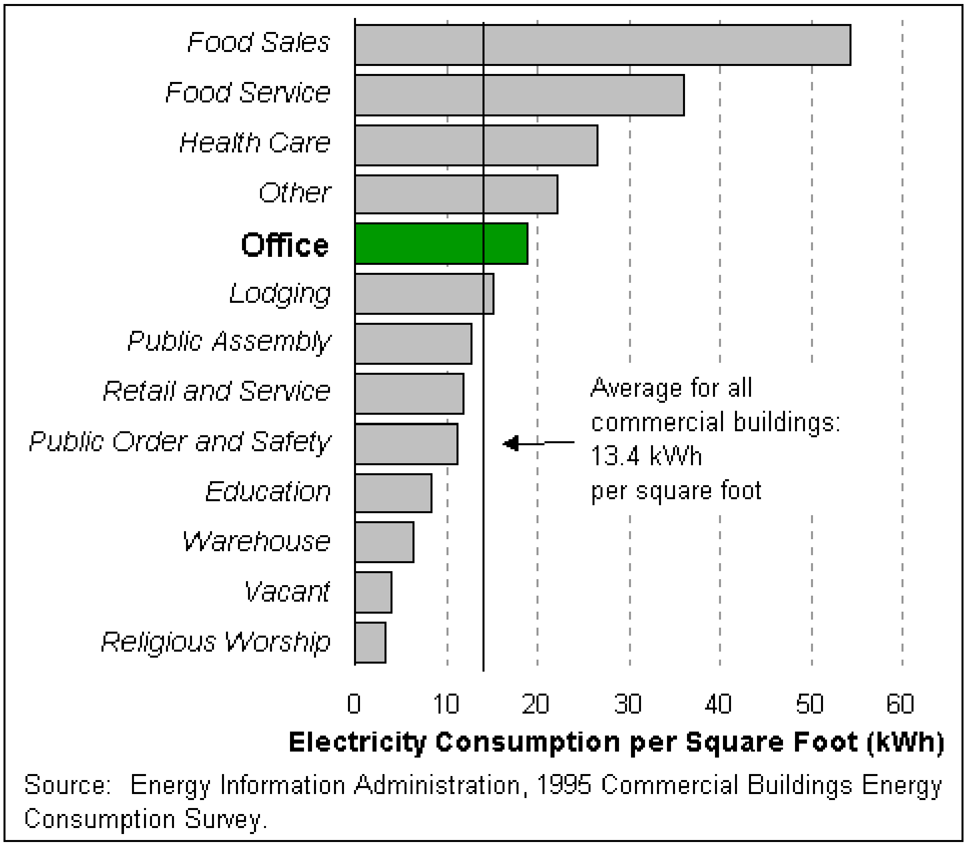
Table 1: Residential Electricity Consumption -- Census Division; EIA

State	Number of Consumers	Average Monthly Consumption (kWh)	Price (Cents per Kilowatt-hour)	Monthly Bill (Dollar and cents)
New England	6,189,701	639	15.89	$101.60
Connecticut	1,453,864	740	18.11	$134.07
Maine	701,335	521	15.38	$80.09
Massachusetts	2,693,548	633	14.67	$92.92
New Hampshire	599,532	619	16.52	$102.28
Rhode Island	432,430	603	14.33	$86.44
Vermont	308,992	573	16.26	$93.19

- **Industrial Load**

Estimating industrial loads is speculative without detailed information regarding the specific technology operating at the specific site. For our purposes, the estimates for electrical loads for the types of industrial entities currently operating in Shelburne provide a reasonable first approximation. Eddie Grinnel, of Eddie's Wheels, which is a relatively large industrial site, by Shelburne standards, has reported that his average daily usage is 50 kWh. If he sized his system to average daily load, his shop would consume less than the upper bound of the commercial load cited above, suggesting system capacity of 7.5-10 kW, if the capacity factor is 0.30. If the capacity factors is lower, he would need a larger system, perhaps 15 kW.

Table 2: Commercial Electricity Consumption – kWh/sq. ft./year[5]



Part II. Impacts

The impacts of wind turbines upon the health of neighboring residents, the ecology, the climate, energy security and safety depend to a large extent upon ***the size and capacity of the turbines*** that will be installed for premises-use. There is a substantial and growing scientific literature demonstrating that ***larger*** industrial wind turbines have serious adverse health effects and adverse effects upon property values. By large, we mean turbines at least ***160-196 ft. tall at hub height***, with name-plate capacities of ***600-660 kW*** and more. Turbines of this size were first studied by the earliest peer-reviewed acoustical studies in Europe.[6] In the first study cited in

5 See http://www.eia.gov/emeu/consumptionbriefs/cbecs/pbawebsite/office/office_howuseelec.htm.

6 See, for example, E. Pedersen and K. Persson Waye, "Perception and annoyance due to wind turbine noise – a dose–response relationship," *Journal of the Acoustical Society of America*, 116(6), December 2004, pp. 3460–3470. For a more complete review of the international studies, all of which were cited by the Massachusetts DEP Wind Turbine Health Impact Study, see "Statement of Dr. Raymond S. Hartman, Presented to the Zoning Board of Charlestown, Rhode Island, Critique of the Massachusetts Department of Environmental Planning (DEP) *Wind Turbine Health Impact Study, Report of Independent Expert Panel*, January 2012," June 5, 2013. The full set of studies is cited in footnote **XX** below.

footnote 6, the turbines were found to disrupt sleep and cause related health effects for a percentage of residents living in close proximity to the turbines. As more studies were completed in Europe by the same researchers, they found greater numbers of residents suffering adverse health effects and diminished quality of life. They attribute these increases in the number of residents affected to the increasing size and name-plate capacities of the turbines. Analysis suggests that the large scale turbines have larger blades that generate both audible and inaudible sounds; the inaudible sounds are infrasound, which is not fully measured by the dBA scales. The infrasound is found to have insidious effects on sleep, inner ear balance, headaches, and a variety of other complaints.

These studies, all cited by the Commonwealth, provide factual information for the PB and its guidelines to the ZBA for premises use turbines. The noises from turbines that are 160 ft. tall (at hub) disrupt sleep and cause related adverse health effects. Of course, ***the height*** and ***capacity*** of the turbines studied by Pedersen and Waye taken together contributed to the disruptive and adverse impacts found. The capacities of those early turbines, 600-660 kW, are orders of magnitude greater than the capacities needed for premises use in Shelburne. We have found no studies that suggesting inaudible infrasound and resulting health effects from wind turbines. We believe any bylaw should error on the side of caution, and as a result we believe a limit of 120 feet in height on any turbine in Shelburne is appropriate.

Section 5: Impacts to climate, energy security, and economics

Evidence we have reviewed to date suggest that smaller premises-use wind turbines ***would not have*** any direct impact upon climate, US energy security or national energy economics. If premises-use wind turbines are put in place, they will generate some electricity at the premise, which will mean that the home/farm-owner or business owner will save money on his/her energy costs, given the substantial subsidies that have been put in place to install the equipment and the price premium at which the premises can sell power back into the grid. Should those subsidies disappear, it is unclear whether the premises would find the use of wind turbines cost effective. Currently we believe there are serious questions of economic viability of small wind turbines in Shelburne. We have discussed this further in Section 2 of this Report.

However, since premises-use wind power involves small capacity turbines, they are unlikely to have an impact on the US climate (reduce carbon emissions). Furthermore, it is not clear how efficient any wind turbines will be in Shelburne, in Massachusetts, or in New England as a whole. The reason is that the "wind assets" in onshore New England locations are relatively poor. For example, according to the National Renewable Energy Laboratory (NREL) of DOE, the wind assets in inland New-England ***are not sufficiently reliable or plentiful*** to generate uninterrupted electricity.

When analyzing the net contribution of wind to supply electric power, one must assess the quality of the wind resource (the asset) that is found at the proposed site. There are a variety of criteria used to characterize how "rich" the wind resource is, including its wind power density

(Wind Class), shear, turbulence, amount of time the wind blows at a given speed, and variation in directionality.[7] Simply put, there must be ***enough wind blowing enough of the time***, without excess turbulence and shear, to make an industrial wind turbine installation (IWT) worth the investment.

These characteristics of wind assets are analyzed and published by a variety of sources. Table 3 presents Wind Classes based upon the wind power density and the related wind speed for an IWT that is 50 meters (164 feet) high. This is well above the height proposed for premises-wind systems and more appropriate for industrial wind turbines. However, the analysis performed by the DOE has relevance for premises-use wind and its potential.

Wind Power Classes of less than 3 (less than 6.4-7.0 m/s or 14.3-15.7 mph) are considered relatively useless and unworthy of development ("good wind resources" are Class 3 or higher).[8] Furthermore, a Wind Power Class of 3 and above may still prove useless and unworthy of development ***if the wind asset is of short duration (that is, blows for a short period of time)***.

Table 3: Wind Power Class Designations[9]

Wind Power Class	50 meters		
	Wind Power Density (watts/m^2)	Wind Speed (m/s)	Wind Speed (mph)
1	<200	<5.6	<12.5
2	200 - 300	5.6 - 6.4	12.5 - 14.3
3	300 - 400	6.4 - 7.0	14.3 - 15.7
4	400 - 500	7.0 - 7.5	15.7 - 16.8
5	500 - 600	7.5 - 8.0	16.8 - 17.9
6	600 - 800	8.0 - 8.8	17.9 - 19.7
7	>800	>8.8	>19.7

Source: Battelle Wind Energy Resource Atlas, for standard sea level conditions

Using these Wind Power Classes, the National Renewable Energy Laboratory (NREL)[10] has provided demonstratives which reveal which sites are most promising for IWTs. The NREL

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7 See http://nwcommunityenergy.org/wind/resource-assessment.

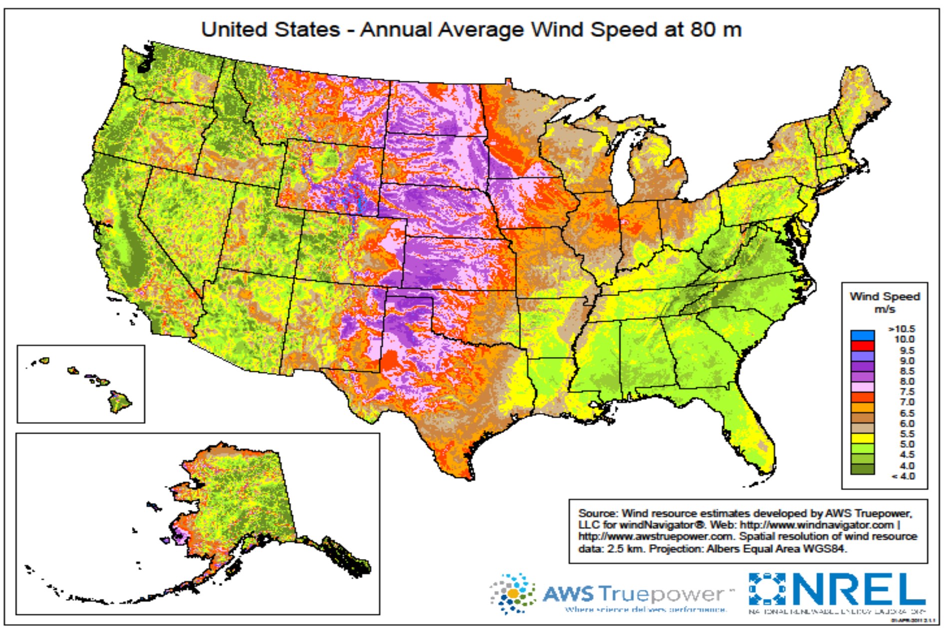
8 The amount of electric energy that can be extracted by a wind turbine is determined by the wind power density. The power density is influenced by two factors: the wind speed and the air density. Power density is directly proportional to the cube of the wind speed (example: if the wind speed triples the power density will increase by a factor of 27.). *At higher altitudes and temperatures however, air density decreases and the power density decreases proportionally.* To make the comparison of wind resource at different sites easier, wind power density has been standardized into wind power classes. Wind classes are often determined at more than one height because wind speeds will vary with height due to the impact of the terrain on wind flow. See http://nwcommunityenergy.org/wind/resource-assessment/Resource%20Assessment/?searchterm=wind flow assessment and http://windeis.anl.gov/guide/basics/index.cfm.

9 Table from *Battelle Wind Energy Resource Atlas* cited at http://nwcommunityenergy.org/images/Density_table.jpg.

10 The National Renewable Energy Laboratory (NREL), located in Golden, Colorado, is the United States' primary laboratory for renewable energy and energy efficiency research and development. NREL is a government-owned,

maps the entire US as to the quality of its wind resources. Figures 1 thru 3 present information on the quality of wind assets, nationwide, in New England (Massachusetts) and in the mid-west corridor (Texas).

According to the NREL, inland wind installations in New England and Massachusetts will find wind assets of poor quality. Wind speeds in Western Massachusetts (Shelburne) are 4-6 m/s, less than Wind Power Class 3. However, the mid-section of the country, from the Canadian border to Texas, clearly offer the richest sources of wind power, with wind speeds generally greater than 6.5 m/s and as high as 10 m/s, which would qualify as Wind Power Classes of 3 or higher; see Figure 1. Examining the states of Massachusetts and Texas more closely clarifies their contrasting wind energy potential. Most of inland Massachusetts (Figure 2) does not offer wind resources sufficient enough to be classified as "good." The inland areas are mostly less than Class 3. There are some sites along the coast that are on the margin – (slightly above 6.0). Comparing these wind resources with those of Texas (Figure 3), we find that Texas has a rich source of wind to be exploited for industrial and premises-use wind, should Texas choose to do so. Indeed, Texas has done more industrial wind investment than any other state.[11]



contractor-operated facility; it is funded through the U.S. Department of Energy (DOE). This arrangement allows a private entity to operate the lab on behalf of the federal government under a prime contract. NREL receives funding from Congress to be applied toward research and development projects. All of the maps presented herein come from NREL, hence DOE. See http://en.wikipedia.org/wiki/National_Renewable_Energy_Laboratory.

[11] The top five US states in terms of IWT MW wind capacity are Texas (10,648 MW), Iowa (4,419 MW), California (4,287 MW), Illinois (2,852 MW) and Minnesota (2,718 MW). See, American Wind Energy Association (http://www.awea.org/learnabout/industry_stats/index.cfm).

Figure 1: Annual Mean Wind Speed of the United States Measured at 80m (262 feet) Height.[12]

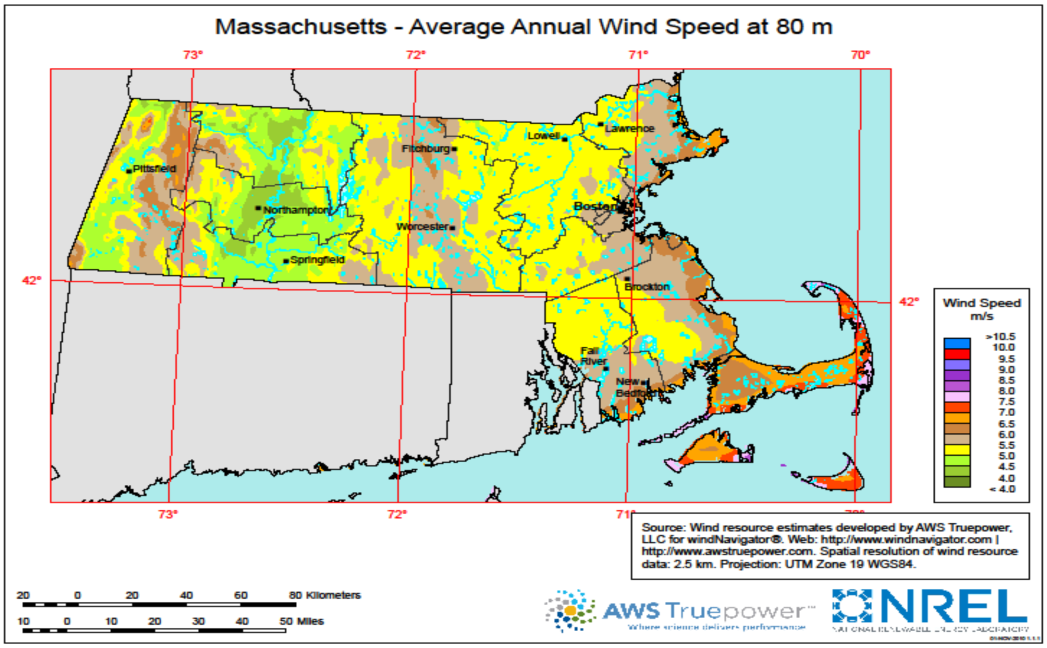


Figure 2: Average Annual Wind Speeds at 80m (262 ft) for Massachusetts[13]

[12] The link for the map for onshore wind resources for continental U.S. is http://www.windpoweringamerica.gov/wind_maps.asp. Once you have linked to that DOE/NREL site, clicking on each state will take you to the wind resource map for each specific state. That is the method used to create Figure 2 for Massachusetts and Figure 3 for Texas.

[13] Source: see prior footnote.

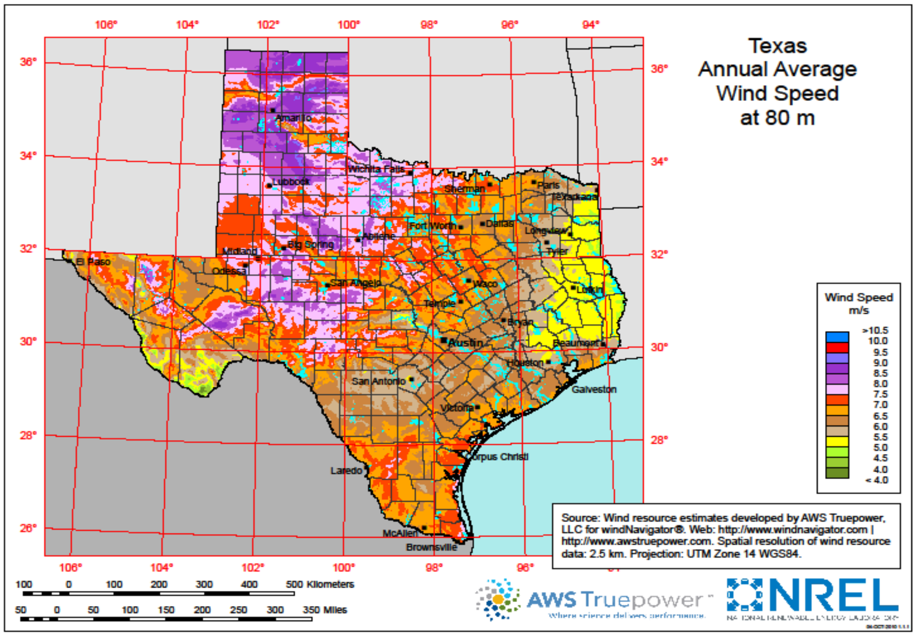


Figure 3: Average Annual Wind Speeds at 80m (262 ft) for Texas[14]

Section 6: Impacts to health (noise – infrasound, sound; flicker)

Most statistical analyses of the impacts of wind turbines on the health of nearby residents have addressed adverse health impacts of ***large-scale Industrial Wind Turbines***, where the ***"large-scale" was originally applied to IWTs that were 160-196 ft. tall (hub height) and had operating capacities of 600-660 kW*** (see my footnote # 6 above). Studies since then have addressed larger-sized turbines, since turbine design has increased 2 to 3-fold over the period 1990-2010. The four other studies discussed in detail by the Mass DEP were completed after the one cited in footnote 6 and studied the impacts of these larger turbines. The studies found that the incidence and severity of adverse health effects increased with the size of the turbines.[15]

[14] Source: see footnote 12.

[15] See

- E. Pedersen and K. Persson Waye, "Wind turbine noise, annoyance and self-reported health and well-being in different living environments," *Occupational and Environmental Medicine*, 64, 2007, pp. 480-486.
- E. Pedersen and P. Larsman, "The impact of visual factors on noise annoyance among people living in the vicinity of wind turbines," *Journal of Environmental Psychology*, 28, 2008, pp. 379-389.
- E. Pedersen, F. van den Berg, R. Bakker and J. Bouma, "Response to noise from modern wind farms in The Netherlands," *Journal of the Acoustical Society of America*, 126(2), August 2009, pp. 634–643.
- D. Shepherd, D. McBride, D. Welch, K.N. Dirks and E. Hill, "Evaluating the impact of wind turbine noise on health-related quality of life," *Noise Health*, 13 (54), September-October, 2011, pp. 333–339.

More recent analyses corroborating the findings of these earlier studies include the following:

- A. Farboud, R. Crunkhorn and A. Trinidade "'Wind turbine syndrome': fact or fiction?" *The Journal of Laryngology & Otology*, 127 (3), March 2013, pp. 222-226.

Raymond Hartman reviewed the five Mass DEP studies in a June 5, 2013 Statement Presented to the Zoning Board of Charlestown, Rhode Island (see footnote 6), which is attached as Attachment A. His conclusions are corroborated by more recent analyses. For example, writing for the College of Family Physicians of Canada, Jeffery**,** Krogh and Horner state that “Industrial wind turbines can harm human health if sited too close to residents … The documented (medical) symptoms are usually stress disorder-type diseases … and can represent serious harm to human health.” Likewise, writing in the *Journal of Laryngology & Otology*, Farboud, Crunkhorn and Trinidade claim “there is ample evidence of symptoms arising in individuals exposed to wind turbine noise. … There is an increasing body of evidence suggesting that infrasound and low frequency noise (caused by the wind turbines) have physiological effects on the ear. … A large body of evidence now exists to suggest that wind turbines do disturb sleep and impair health at distances and sound pressure levels that are permitted in the United Kingdom.” Nissenbuam, *et al*. “conclude that the noise emissions of IWTs disturbed the sleep and caused daytime sleepiness and impaired mental health in residents living within 1.4 km of the two IWT installations studied. Industrial wind turbine noise is a further source of environmental noise, with the potential to harm human health. Current regulations seem to be insufficient to adequately protect the human population living close to IWTs. Our research suggests that adverse effects are observed at distances even beyond 1 km.”

As noted in Section 4, the turbines being proposed for premises-use in Shelburne are considerably smaller than those analyzed in this literature, suggesting that some of the noise impacts, particularly infrasound, should be less. That is a good thing for the residents of Shelburne. Relevant capacities for residential premises usage should be at most 10 kW. However, it is possible that mechanical noises will be greater for the smaller turbines and the possibility of infrasound should not be dismissed.

Most of the analyses of large-scale IWTs suggest that adverse health effects are integrally connected to the disruption of sleep. The same concerns will likely arise with smaller-scale premises-uses turbines. If premises-use turbines create noise at night, in quiet rural areas like Shelburne, they will disrupt sleep and cause many of the stress-induced illnesses that accompany constant sleep disruption induced by any industrial or man-made noises. As neighbors, we all recognize that if our dogs bark loudly all night or if some residents have loud parties all night, there will be sleep disruption, complaints to the police and perhaps litigation. Premises-use turbines should be treated no differently than any other mechanical activity. If they are quiet enough, then they will not disrupt sleep or annoy people during the day. As previously noted, without any studies to indicate otherwise, inaudible infrasound seems to be less of a problem with the smaller sized turbines;

- M. A. Nissenbaum, J. J. Aramini and C. D. Hanning, “Effects of industrial wind turbine noise on sleep and health,” *Noise and Health*, September-October 2012 Volume 14, Issue 60, pp. 237-243.
- R. D. Jeffery**,** C. Krogh and B. Horner, **“**Adverse health effects of industrial wind turbines,” *Canadian Family Physician*, the official journal of the College of Family Physicians of Canada, May 2013.

What is needed is a proper set of noise guidelines for the SPA to impose on any permit for premises-use turbines to avoid abusing the rights of abutting or nearby neighbors. Two local but nationally known acousticians have studied mechanical noises generally and turbine noises specifically. They have gathered and reported results from a variety of studies that indicate noise levels at which annoyance and sleep disruption occur. They have prepared a summary document of noise-audible levels that will and will not disrupt the lives of neighbors, based upon a large sample of case studies. Their document is presented as Attachment B, and is titled "Wind Turbine Noise Complaint Predictions Made Easy." Some excerpts for that document are the following (some emphasis in original; some added):

- "In 1974, the USEPA published a methodology that can predict the community reaction to a new noise. A simple chart can be used that shows the community reactions (y-axis) versus noise level (x-axis). This chart was developed ***from 55 community noise case studies (black squares)***. The baseline noise levels include adjustments for the existing ambient, prior noise experience, and sound character. The predicted wind turbine noise level is plotted on the 'x-axis' and the predicted community reaction is determined by the highest reaction, indicated by the black squares. Here are some examples: ***32 dBA no reaction and sporadic complaints***, ***37 dBA widespread complaints***, ***45 dBA strong appeals to stop noise and 54 dBA vigorous community action,*** the highest."

- "The International Standards Organization (ISO) determined that ***25 dBA represents a rural nighttime environment.*** The World Health Organization (WHO) found that noise below 30 dBA had *no observed effect leve*l (NOEL) and 40 dBA represented the *lowest observed adverse effect leve*l (NOAEL) for noise sources that excluded wind turbines. Wind turbines produce strong low frequency energy that may reduce the WHO cautionary levels by 5 dB, thereby showing closer agreement with the 33 dBA recommendations."

- "Pederson & Waye (2004) research found that when wind turbine noise levels reached 35 dBA, ***6% of the population was highly annoyed,*** and this rapidly ***increased to 25% at 40 dBA."***

- "Independent researchers recommend that noise levels should not ***exceed 33 dBA,*** which is near the upper limit for *sporadic complaints,* or ***a maximum increase of 5 dB [above ambient],*** whichever is more stringent."

The recommendations put forward above are directed at audible sound, that is, sound which can be measured in dBA. Rand and Ambrose have also studied the generation, measurement and impacts of inaudible noise – infrasound. We understand that infrasound is less of an issue with smaller turbines. Rob Rand warns against infrasound of the larger small turbines, which he measures in **Hertz**. His research allows him to state that those larger small turbines with slower rates of blade spinning which fall inside the range of frequencies identified by the Navy as "nauseogenic" (where people get motion-sick including vomiting) **is in the range of 0.1 to 1 HZ.** He has usually found these levels in turbines with capacities > 30-45 kW. If anything, the smaller turbines spin more quickly, which should eliminate infrasound. The mechanical noise from the spinning and shifting with the wind can be extremely loud and disturbing, but that noise will be limited though the limitations on dBA.

Based upon the body of research of Ambrose and Rand; their compilation of 55 community noise studies in Attachment B; their review of the audible and infrasound noises at many sites; and our review of the literature; we recommend the PB develop zoning guidelines for the SPA for noises emitted from premises-use turbines that reflect the following:

WAC recommendations for zoning bylaw regarding audible and inaudible noise

a) Current residents have purchased and developed their properties in order to enjoy the rural life and quiet offered by Shelburne. They have a first right to enjoy that property and its rural characteristics and amenities.

b) Introduction of a premises-use wind turbine should be critically examined like the introduction of any other mechanical technology – e.g., a small track for motorcycle racing; a stone processing plant, etc. If any such new technology is too noisy for too much of the day and night, it should not be allowed.

c) Noise limitations for wind turbines have been examined and vetted by nationally recognized acousticians. Those limitations are: the noise is not to exceed 32 dBA or a maximum increase of 5 dBA above ambient, whichever is more stringent. These two thresholds are nearly equivalent in rural towns like Shelburne, since the ISO (International Standards Organization) finds rural night-time ambient noise to be 25 dBA, 5-7 below 32. (See attached letter Attachment B-1 detailing ambient in Ashfield community at 24-30 dBA) Even at 32 dBA, existing studies suggest there will be some annoyance and complaints. (See Attachment B). We advise any bylaw should have a limitation on Hz of the turbines, just to rule out health problems that may arise from infrasound. These limitations should be measured at the site of any and all abutting or nearby properties. We believe a limitation that any turbine installation may not have noise exceeding 5 dBA above ambient at any property line is the proper limitation for Shelburne.

d) Shelburne should require any wind turbine applicant submit certified acoustic tests of the turbine being applied for, under worst-case conditions including furling and over-speed protection. Refusal or inability of the manufacturer to provide such data must not be accepted as an option to waive the requirement. If the applicant cannot supply those data, then the application would not qualify for permitting.

e) ***Caveat Emptor – Builder Beware***. If an applicant submits certified acoustic tests that pass the limits set above, but the results of those tests are refuted by later testing by the town or neighbors, the builder of the premises-use turbine is liable. He/she must either mitigate the noise or shut down the turbine.

Flicker

People who suffer from photosensitive epilepsy and experience seizures in response to certain environmental triggers may be affected by flicker. This condition is rare, but research has shown that three flashes per second (120 per minute) or slower has a low risk of inducing seizure in sensitive individuals. As such, the flicker rate should be no more than three per second. A typical large three-bladed wind turbine rotates significantly slower than that. However, a premises use turbine will rotate more quickly than that.

Shadow flicker should also be addressed. Builders should be required to analyze shadow flicker and determine where the shadows fall and for how long during the year. We recommend that shadow flicker should not affect any occupied building. [16]

Small wind energy systems shall be sited in a manner that does not result in significant shadowing or flicker impacts. The applicant has the burden of proving that this effect does not have significant adverse impact on neighboring or adjacent uses either through siting or mitigation.

Section 7: Impacts to ecology (birds, bats)

IWTs are found to kill birds and bats. We understand that bird-kill and bat-kill rates for IWTs are significant. We understand that IWTs are given special dispensation to kill as many eagles and other birds as they do, despite the fact that the penalties for other technologies for bird-kills and eagle-kills are substantial

With premises-use turbines, there are bound to be some bat-kills and bird-kills. However, the rates will likely be less, since the devices are smaller. We are unaware of any studies at this time with regard to impacts to birds and bats by smaller wind turbines.

Section 8: Visual nuisance impacts

We recommend that the premises-use turbines be constructed so that they blend into the rural setting in which they will be built. We concur with the recommendations by Tighe & Bond regarding visual impact analysis for applicants as outlined in the report to the Planning Board dated December 10, 2012.

Section 9: Safety considerations (ice, falling, blade throw, lightning etc.)

A setback of two (2) times the height of a turbine is purely a safety setback in case of mechanical issues. This distance won't even begin to address community noise impact potential and it should

[16] See http://www.environ.ie/en/Publications/DevelopmentandHousing/Planning/FileDownLoad,1633,en.pdf, p. 33.

not be considered a useful distance for noise setback. The issue of noise thresholds is addressed above.

Part III. Legal considerations

> ***"A myth has grown up in the midst of natural resource decision making that good science can, by itself, somehow make difficult natural resources decisions for us and relieve us of the necessity to engage in hard work of democratic deliberations that must finally shoulder the weight of those decisions." Mark Rey, Assistant Secretary USDA***

Section 10: Robust ordinances – what are the elements of a good ordinance or bylaw?

The introductory language to our zoning bylaw provides in part:

> ***The Shelburne Zoning Bylaws are enacted pursuant to Chapter 40A of the General Laws and the Home Rule Amendment to the Massachusetts Constitution, to promote the health, safety, convenience and general welfare of the inhabitants of the Town of Shelburne, to protect the value of land and buildings, to conserve natural resources, to preserve the Town's cultural heritage, rural character and open farmland, and to facilitate residential, commercial and industrial development in a responsible manner.***

A fair reading of the introductory language of our zoning bylaws should lead one to conclude that commercial and industrial development "in a responsible manner" takes a back seat to the interest of promoting the "health, safety, convenience, and general welfare" of the town inhabitants. When determining appropriate regulation for on-site wind turbine use, we believe the above referenced bylaw language should be adhered to.

Zoning ordinances are not perfect and usually cannot resolve all land use conflicts. Zoning ordinances are designed to systematically prevent land-use disputes relegating specific land uses to areas where those uses cannot interfere with neighboring land uses. The more specific and detailed the regulation the more likely conflict will be avoided.

Wind turbines are somewhat unique for the Town of Shelburne, as the most feasible location for turbines are in residential neighborhoods on hilltops. Obvious concerns for aesthetics, noise, and flicker require specific regulation and clarity. This enables landowners contemplating a wind turbine to easily discern the regulatory requirements. More importantly landowners in those areas in which turbines might be potentially located can be assured that in the event a wind turbine is proposed for a location, it will not interfere with their use and enjoyment of their property.

Conflict arises when there is a dispute between two or more landowners over incompatible land uses. When aesthetics and noise are involved (particularly during the evening when most people sleep and do not want to be disturbed), this increases the level of anxiety and potential for conflict.

The American Wind Energy Association (AWEA) defines and adverse visual impact as an "unwelcome visual intrusion that diminishes the visual quality of an existing landscape."[17] AWEA explains that "changes can be perceived as visual intrusions generally result from the introduction of visual contrast to the existing scene, based on differences in form, line, color, and/or texture." Aesthetic concerns do evoke powerful emotions in aggrieved landowners.[18]

Even though a potential project meets regulatory criteria, this does not limit the ability of a landowner to challenge the use as a "nuisance" by bringing a civil action to prohibit any continued interference with the use and enjoyment of the subservient landowner. This may or may not include the Town as a potential defendant. We believe it is incumbent upon the Town to pass a bylaw that affords the ability of landowner to potentially use a wind turbine to generate electricity for their home and/or business use***, provided it does not cause any type of interference with neighboring property owners use and enjoyment of their property.***

Section 11: Complaint forms, how to manage subsequent problems if they arise

Complaints and lawsuits over wind turbines are on the rise world-wide. To the extent these complaints and lawsuits represent the fears and concerns of members of the community in which a wind turbine is sited, we need to be sure that any bylaw passed will assess the risks to people and property and work to minimize conflict.

In the event a conflict arises by and between landowners regarding the use of a wind turbine, or for that matter any use in which conflict arises, those that object must feel their interests are being protected equally to the one that is creating a potential problem. Many neighbors feel conflicted when faced with a decision whether or not to voice an objection to a use that is having an adverse impact in fear of retaliation or conflict with a neighbor.

Currently a landowner wishing to lodge a complaint concerning potential illegal land use requires complaints be made to the zoning enforcement officer. Alleged violations of Board of Health regulations require complaints be made to the local board of health or the State Board of Health. We believe a confidential on-line complaint form should be made available to anyone that wants to lodge a complaint for zoning or health code violations. The Town of Fairhaven, Massachusetts has an excellent complaint form that goes directly to the Board of Health for wind

[17] *Wind Energy Association Wind Energy Siting Handbook,* 5-27 (2008).

[18] Joseph Haupt, "A Right to Wind/Promoting Wind Energy by Limiting the Possibility of Nuisance Litigation," *Journal of Energy & Environmental Law,* 256, Summer 2012.

turbine impacts. We believe at a minimum this type of system should be set up for anonymous reports of complaints related to potential zoning violations not just for wind turbines.[19]

Section 12: Litigation that has arisen with premises-use turbines. Outcomes?

As previously indicated, even though a wind turbine could meet regulatory criteria, it still could have an adverse impact on a neighbor resulting in litigation for a nuisance claim. The following decision from a New Jersey Court in 1959 sets forth in detail the issues that are present in potential locations for turbines in the Town of Shelburne.

> "The noise produced is offensive because of its character, volume and duration. It is a sound which is not only distinctive, but one which is louder than others and is more or less constant. Its intrusive quality is heightened because of the locality. The neighborhood is quiet and residential. It is well separated, not only from commercial sounds, but from the heavier residential traffic as well. Plaintiffs specifically chose the area because of the qualities and the proximity to the ocean. Sounds which are natural to this area-the sea, the shore birds, the ocean breeze – are soothing and welcome. The noise of the windmill, which would be unwelcome in most neighborhoods, is particularly alien here." [20]

Nuisance litigation over wind turbines is developing law. Nuisance claims can be brought in Massachusetts (MGL Chapter 243). Nuisance is a "nontrespassory invasion of another's interest in the private use and enjoyment of land."[21] The reasonableness of a particular land use is highly fact specific involving many factors including the benefits and harms of the use.[22]

Even in a conservative state like Nevada nuisance litigation has been successful against a wind turbine on private land. In this case the wind turbine was for the benefit of a single property; therefore, the Court determined there was no overriding public good that trumped a neighbor's right to be free of disturbance.[23]

Shelburne has adopted a "premises use" requirement for any wind turbine. This actually enhances the potential success for a civil action claim of nuisance in that there is no overriding public good that has to be weighed against the neighbor's interests of being free from unreasonable interference.

Although many municipalities we surveyed reported no complaints with smaller wind turbines (less than 110'), Ancram, New York provides an ideal case study of small wind turbine

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[19] See http://fairhaven-ma/.gov/pages/FairhavenMA_Health/complaintform.

[20] See *Rose v. Chaikin, 453 A. 2nd* 1378, 1382 (N.J. Super. Ct. Ch. Div. 1982.

[21] *Restatement (Second) of Torts*, Sect 821.

[22] *Id*, Sect. 826, 828.

[23] http://www.nevadajudiciary.us/images/advanceopinions/129nevadvonpno9.pdf)

installations gone terribly wrong. We urge the Planning Board to review the support materials in this regard. This small town, like Shelburne, wanted to do the right thing allowing alternative forms of energy to be included in their town. The turbine sales person and the property owners assured town officials there would be no adverse effects from the wind turbines. Soon after installation, the representations were found to be fictitious. Currently the town and neighbors are involved in litigation concerning these turbines.

The studies referred to in Section 2 of this Report and the other information and evidence we have reviewed, leads us to conclude that representations made by small wind turbine manufacturers should be questioned. This word of caution is not only directed to a special permit granting authority, but also any person or business who is contemplating acquiring a small wind turbine. We believe a "buyer beware" and no tolerance policy of adverse effects from turbine installations should be adhered to in any premises use bylaw.

Section 13: Recommendations:

The Wind Advisory Committee has voted to provide the following recommendations to the Town of Shelburne Planning Board and to the residents of Shelburne as we consider a new Premises Use Wind Turbine Bylaw:

<u>Height Limit:</u> The Wind Advisory Committee recommends that any premises-use turbine does not exceed 120 feet from grade to the tip of the blade.

<u>Capacity:</u> The Wind Advisory Committee recommends that the output of nameplate capacity be limited to 10 KW for residential and 30 KW for agricultural/business use.

<u>Excess:</u> In order to comply with the intent that the output be primarily for premises use, the Wind Advisory Committee recommends that the rated name capacity be restricted to the smallest unit available to cover the intended premises use.

<u>Noise:</u> The Wind Advisory Committee recommends that the noise limit of any wind turbine shall not exceed 5 dB above ambient at any lot line and the nearest inhabited residence. The ambient level shall be established by the applicant prior to the submission of an application by a protocol to be determined.

<u>Flicker:</u> The Wind Advisory Committee recommends that the By-law shall not allow any flicker affecting occupied buildings.

<u>Aesthetics:</u> The Wind Advisory Committee recommends to the Planning Board that they take visual impacts and property values considerations into account in the permitting process.

<u>Setback:</u> The Wind Advisory Committee recommends that the setback be double the height of the blade tip from any roadway, structure, or property line.

<u>Certification:</u> The Wind Advisory Committee recommends that any premises-use wind turbine must be an approved turbine on the list certified by the Small Wind Certification Council or other certification agency as approved by the State of Massachusetts.

One turbine per premise: The Wind Advisory Committee recommends that only one turbine be allowed per premises.

Conclusion:

Because the wind industry is changing and every location has unique characteristics, any by-law regulating installation and use of a wind turbine must allow for the circumstances of each particular case, yet require sufficient information to make an informed decision whether the rights of all parties are protected. The issues to be considered have been set out in this document according to the best information available at this time. It is clear that even setting limits on size in height or output and setbacks in specific distances may not adequately meet that goal. However, there is a need for some limits as a starting point to eliminate applications that cannot succeed. While the proposals in this report provide guidelines in this respect, ultimately a decision of whether a specific proposal may go forward must rest with the permitting authority based on interpretation of all of the factors involved. It is hoped that this report gives a better understanding of what is involved in permitting an application for a wind turbine.

Respectfully Submitted:

Town of Shelburne Wind Advisory Committee to the Planning Board
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Judith Truesdell, Member/Clerk
Michael Parry, Member
Raymond S. Hartman, Member
Thomas Webler, Member
John Wheeler, Member/Planning Board Representative
Lowell LaPorte, Member/ZBA Representative
Robert Jaros, MD, Member
Eugene Butler, Member