**Jonathon Idman**

**From:** Joanne Levesque <joanne@levesque.us>
**Sent:** Monday, April 29, 2019 4:12 PM
**To:** Jonathon Idman
**Subject:** Re: Vineyard Wind - submission for the public record - "Safety Concerns"
**Attachments:** Amherst College Department of Astronomy.docx

I would like to ADD to my previous submission regarding Vineyard Wind "Safety" concerns.

I am attaching a document which includes some very interesting information about wind turbines in general but to my concern - the document shares the content of Professor Manwell's writing (from long ago) on wind turbine safety considerations.

My hope is that the Cape Cod Commission takes the time to fully vet safety considerations so that public health and welfare is properly protected. I can honestly state that Massachusetts "land based" wind permitting OMITTED any reference to the stated concerns of Professor Manwell. Consider his statement that **the engineering solution to protecting the public from ice throw is a "simple one: a turbine must not be sited anywhere near a populated area. We might comfortably define "anywhere as one mile."**

**Are the public, including commercial fisherman and recreational boaters, going to be allowed within one mile of any one of these 84 massive turbines?**

Here is an excerpt from UMASS Wind Energy Center's James Manwell as read in his textbook entitled: ***"Wind Energy Explained / Theory, Design and Application" by J. F. Manwell et al. Professor James Manwell***

***While high winds and lightning are the most common environmental challenges, ice accreting on a blade is also a concern. Clearly this is a site-specific problem. Ice can be a frequent occurrence in northern and far southern latitudes yet nonexistent at the mid-latitudes. Ice can cause a blade imbalance and resultant vibration severe enough for the turbine's onboard computer to initiate an automatic shutdown. Additionally the possibility of an 'ice throw' near a populated area needs to be carefully evaluated. When the V82 is operating at its design speed of 14 RPM each blade tip is moving at 63 meters/sec (141 MPH). In 2006 a report by another leading turbine manufacturer, GE Wind Energy noted that under the right conditions ice can be thrown several hundred meters.***

***The 141 MPH velocity of this projectile would be faster than any baseball ever hit from any ballpark. Typically the resultant velocity of a well hit 44 meters/sec (100 MPH) fastball is about 55 meters/sec (125 MPH). So let us imagine a baseball-sized chunk of ice departing home plate at Boston's Fenway Park not for Lansdowne Street but for the Massachusetts Turnpike and points beyond. Clearly, if a turbine in an ice-prone latitude is going to be sited near a populated area, careful evaluation of ice-throw hazards is requisite. The engineering solution to this problem is a simple one: a turbine must not be sited anywhere near a populated area. We might comfortably define "anywhere" as one mile.***

Thank you for your time and attention,

Best Regards,

Joanne Levesque / Duxbury, Ma

On Mon, Apr 29, 2019 at 3:29 PM Joanne Levesque <joanne@levesque.us> wrote:

To: Jonathon Idman
Chief Regulatory Officer CCC
cc: Kristy Senatori - Executive Director, CCC
Re: Public Hearing / Vineyard Wind project / Safety concerns

Good Afternoon,

I am prompted to share a picture taken several years ago up in Dixville Notch, New Hampshire in order to stimulate some vetting relative to safety concerns surrounding industrial wind facilities.

I have yet to see any discussion relative to public safety concerns for commercial fisherman, recreational fisherman and other mariners.

Aside from what I consider to be the very deadly serious radar interference issues I've seen little mention of the need for proper safety setbacks.

Very simply, this signage, posted by the wind developer speaks very clearly to the dangers inherent with being in the vicinity of an industrial wind turbine...not to mention being in the vicinity of 84 turbines spread over 282 square miles of our precious ocean waters.

I urge proper consideration of all adverse impacts associated with this vast array of industrial machinery slated for our nearby ocean waters; in this case I raise the very real danger pointed to by this sign:

"***WARNING!*** ***DO NOT PASS THIS POINT FOR YOUR SAFETY***
***ICE AND OTHER HEAVY OBJECTS CAN BE THROWN LONG DISTANCES FROM WIND TURBINE TOWERS AT HIGH VELOCITY AND CAN KILL!"***

It is disturbing to me that I have read no detailed warnings among Vineyard Wind's submissions for approval. It is if this topic of concern does not exist. The reality is that assuring public safety should be priority.

Thank you for your time and attention.

Best Regards,

Joanne Levesque
Public Health and Safety Advocate
Duxbury, Ma

# Amherst College Department of Astronomy
# 2013 Interterm

## Sunday Seminar and Field Trip

## Wind Turbines: *The* Sustainable Resource?

All majors encouraged
Dates: Afternoon seminar Sunday January 20th, Field trip Monday January 21st
Times: Seminar 1300 – 1500 HRS, field trip departs Merrill @ 1000 HRS, Jan 21st
Location: Merrill 220, Amherst College
Contact: Henry Parker Hirschel – hhirschel@amherst.edu
Sponsored by: Amherst College Department of Astronomy

### Outline

The short answer is yes: wind energy is *one* of our sustainable alternatives. The long answer is considerably more complex and will be the focus of an afternoon seminar and daylong field trip (departing the following morning) to an operational 960 kilowatt wind turbine at a ski-area in Charlemont, Massachusetts.

We will take a chairlift to the mountaintop and hike a half mile to the turbine. There, with the great 90 foot blades rotating at 27 RPM above our heads (and quite probably the winter wind howling out of the northwest) the general manager of the Berkshire East ski area, Mr. Jon Schaefer, will give us a detailed presentation on the permitting, planning, transportation, construction, operation and maintenance germane to this sustainable (and financially successful) energy alternative. The turbine provides > 90% of the energy used by Berkshire East. Alternatively it is capable of powering 300 homes or supplying about a third of the College's energy needs. En-route to the turbine we will also make a brief stop at the newly commissioned 2 MW solar facility at Northfield, Massachusetts.

The instructor's reference source for this seminar and much of the information that follows is "Wind Energy Explained / Theory, Design and Application" by J. F. Manwell *et al.* Professor James Manwell completed his undergraduate studies at Amherst College. He is currently the head of the University of Massachusetts Wind Energy Department in the School of Engineering and is considered one of the foremost experts on wind energy in the nation. If you are an upper-classman with a rock solid physics and calculus background, you may wish to investigate his upper

level course on wind energy. A copy of Prof. Manwell's textbook will be available on the reference shelf in the Merrill Science Library.

INTRODUCTION:

While Don Quixote has been tilting at his mechanical windmill for over four hundred years, it was not until the end of the last millennium (California in the 80's and 90's) that the wind's kinetic energy was converted into electricity on a commercial scale. These first generation turbines typically produced 50 KW or less. At the cusp of this century the second generation wind turbine appeared in the United States. These machines are larger, more sophisticated, and much more powerful (600 KW to 7,000 KW) than their forebears. Even larger offshore models are now in development.

The first (and second) laws of thermodynamics remind us that a perpetual motion machine is impossible. Be that as it may, we can correctly state that a wind turbine's 'fuel' is free albeit not perpetually abundant. Simply stated, a wind turbine converts the wind's kinetic energy into rotary motion and then to electricity. The Betz Limit correctly hypothesized by William Betz in 1926 states that only 59% of the wind's energy can be captured from an *idealized* rotor. Modern turbines attain 70 to 80% of the Betz limit.

ENGINEERING OVERVIEW:

When compared to its wooden windmill forebears, a wind turbine is an extraordinarily complex piece of machinery. Remember that a *windmill* converts wind energy into mechanical motion (e.g. grinding grain or pumping water) and a *wind turbine* converts energy into electrical power. These machines are carefully designed and repeatedly tested in the crucible of remote untended locations (occasionally to destruction). While turbines are fabricated out of readily available materials, they are controlled by state of the art components unavailable a quarter of a century ago. Each is manufactured and assembled with the utmost precision.

The most critical structure from an engineering standpoint is the variable-pitch three-bladed turbine/rotor assembly. Each blade has a centrally reinforced (span wise) fiberglass spar with a carefully crafted and balanced two-piece external fiberglass airfoil. Lighter and more durable carbon composite blades have recently become available. At this writing they are eight times more expensive.

An anemometer interfaced with an onboard computer enables the machine (the rotor and nacelle assembly) to mechanically orient itself into the wind. This computer also varies the pitch (angle of attack) of the blades with the wind's intensity. In a threatening high wind or storm scenario the machine will turn upwind, feather its blades for zero lift, and lock its hydraulic brake. Thus configured, the wind turbine is capable of surviving winds in excess of 58 meters/second (130 MPH).

TYPICAL OUTPUT, WEIGHTS, & DIMENSIONS:

The most common wind turbines in the world are built by the Vestas Corporation in Denmark. This company has installed over 41,000 machines. Their most popular model is the Vestas V82.

At its designed operational speed of 14 RPM, this 1,650 KW turbine is producing over 2,200 horsepower (1 KW is the equivalent of 1.34 HP). Remember that 1,000 kilowatts (KW) equals 1 megawatt (MW). You may recall the following example from your middle school science: a bright "old fashioned" tungsten filament light bulb consumes 100 watts/hour. Thus, ten 100 watt bulbs use 1 KW/hour or simply 1 KW. Therefore, when operating at its rated output, the Vestas V82 can illuminate 16,500 one hundred watt light bulbs. Note that as of January 2012, 100 watt tungsten light bulbs will no longer be available in the United States.

When viewed up close, this machine is massive … almost otherworldly. It weighs nearly 250 tons (more than three fully loaded Boeing 737 airliners). The V82 consists of three major sub-assemblies: the three-bladed rotor and hub assembly noted above, a weather-tight nacelle housing the internal machinery, and a three-piece tubular support tower. The rotor/hub assembly weighs 47 tons (a single turbine blade > 7 tons), the nacelle 57 tons, and the tower 138 tons. The 115 cubic yard reinforced concrete foundation is not included in these weights.

The V82 is 396 feet from the foundation pad to a vertical blade tip. Each blade is 135 feet long and the hub height is 269 feet. There are approximately 300 rungs on the internal service ladder. It is interesting to note that by the process of natural selection there are few seriously out of shape onsite service or engineering personnel.

One of the largest turbines ever planned, the Vestas V164, is about to begin engineering and certification trials. It will produce 7 MW. This machine will have truly prodigious dimensions: 605 feet from foundation to vertical blade tip; a 538 foot rotor diameter (roughly the entire area of Fenway Park in Boston); and a 262 foot blade length (nearly twice the length of a V82 blade). Manwell reminds us that blade mass scales as the cube of the blade radius, thus each blade will be eight times heavier than the V82's or 56 tons apiece. The V164 could provide over twice the energy needs of the College (In February the yearly peak hourly load is approximately 3.2 MW).

ENGINEERING DETAIL:

The internal machinery of a typical turbine can be described as follows: at the forward end (front) of the nacelle, the input shaft from the exterior rotor is bedded in a large thrust bearing fixed to a heavily cast nodular steel sub frame by a robust trunion (anchoring) assembly. The input shaft, which is over one foot in diameter, continues aft for about three feet where it is then coupled to a planetary gear transmission that converts the 14 RPM high-torque input from the rotor shaft into a 1,200 RPM low-torque output shaft. The low torque shaft continues aft where it is coupled to the generator. The generator develops 600 volts at 60 HZ. This energy is then sent to a transformer in the base of the machine and the voltage is increased to an amount that is compatible with the local grid, typically 13,800 volts. There are secondary electric motors within the rotor hub that synchronously pitch the three blades. And two additional motors turn the rotor/nacelle assembly into the wind.

The turbine is essentially self-tending and relays its operational data (and service needs) to a monitoring site. Should any anomalies occur that are not detected by the onboard computer, an engineer can shut down the entire system remotely. This is useful if severe wx is forecast.

ENGINEERING AND ENVIRONMENTAL CHALLENGES:

In a sense a wind turbine is analogous to a cargo ship on the North Atlantic in winter; both have deliberately been placed in harm's way and must be able to survive in an extreme operating environment. While the machinery on the ship has the benefit of the constant attention of a chief engineer and his minions, the turbine is isolated and must be self-tending.

The most frequent environmental challenge facing a turbine is high winds. The aforementioned Vestas V82 when exposed to wind beyond its operational envelope will shut down at wind speeds greater than 20.1 meters/sec (45 MPH). Here is a more detailed explanation of the shutdown sequence: 1. The onboard computer will first turn the rotor and nacelle assembly upwind (into the wind) 2. The rotor-blades will be feathered to the zero-lift position 3. A hydraulic disk brake will lock the input shaft (this also locks the rotor) 4. The onboard computer will alert engineers at their monitoring station of the machine's off line status.

Another serious threat to a wind turbine is lightning. Clearly, a metal and fiberglass structure atop an exposed mountain ridge is at serious and repeated risk of lightning strikes. *Every* external and internal component must be grounded. Even with the most careful attention to the above, lightning damage is not uncommon. When a strike does occur it is frequently the blades that take the full force of the discharge. Damage can be so severe that a blade will have to be replaced. This is an expensive repair. It is useful to note that turbines are typically located at the end of densely layered gravel and crushed stone service road that is requisite for the construction, repair, and removal of heavy components throughout the machine's quarter century service life. The cost of this road is site dependent and can be a significant fraction of the turbine's total expense.

While high winds and lightning are the most common environmental challenges, ice accreting on a blade is also a concern. Clearly this is a site-specific problem. Ice can be a frequent occurrence in northern and far southern latitudes yet nonexistent at the mid-latitudes. Ice can cause a blade imbalance and resultant vibration severe enough for the turbine's onboard computer to initiate an automatic shutdown. Additionally the possibility of an 'ice throw' near a populated area needs to be carefully evaluated. When the V82 is operating at its design speed of 14 RPM each blade tip is moving at 63 meters/sec (141 MPH). In 2006 a report by another leading turbine manufacturer, GE Wind Energy noted that under the right conditions ice can be thrown several hundred meters.

The 141 MPH velocity of this projectile would be faster than any baseball ever hit from any ballpark. Typically the resultant velocity of a well hit 44 meters/sec (100 MPH) fastball is about 55 meters/sec (125 MPH). So let us imagine a baseball-sized chunk of ice departing home plate at Boston's Fenway Park not for Lansdowne Street but for the Massachusetts Turnpike and points beyond. Clearly, if a turbine in an ice-prone latitude is going to be sited near a populated area, careful evaluation of ice-throw hazards is requisite. The engineering solution to this problem is a simple one: a turbine must not be sited *anywhere* near a populated area. We might comfortably define "anywhere" as one mile.

Temperature extremes are yet another engineering challenge. Be it the 120-degree heat of a remote equatorial desert or the prolonged subzero cold-soak of the Arctic Circle, each venue presents extraordinary demands for cooling, heating and lubrication. Offshore turbines in a corrosive salt environment present an additional set of engineering challenges.

INTERCONNECTION PROBLEMS WITH THE GRID:

Wind turbines produce their rated power on an intermittent basis. Depending on the site, the machine may produce as little as 20% of its rated power on a year-over-year basis. Even at a site with exceptionally consistent winds, an offshore venue in the North Sea for example, the turbine may only produce 80% of its rated power.

The intermittent power noted above is a major problem when interfacing turbines (and solar panels) with the grid. The network was originally engineered for slow increases and decreases in power. For example on a hot August morning, there is a steady and predictable increase in demand as more residential and commercial air conditioners come on line. Thus the engineers at the power plant are able to gradually ramp-up the plant's production in synch with increasing demand. Now, if a wind turbine that is "on-grid" and producing its maximum power suddenly goes off line due to an auto-shutdown from too much wind, a mechanical fault, etc., this causes a serious strain on the local electrical infrastructure. Tripped circuit breakers or even blown transformers are a possibility. One solution is to build a more robust grid as has been done in Scandinavia. Unfortunately, this is an expensive, time-consuming endeavor.

The first large-scale grid was built in New York City in 1882 by Thomas Edison. The company that operates it still bears his name, Consolidated Edison. Unfortunately many parts of the Northeast grid are nearly as antiquated as their historic predecessor's prototypical equipment. In fact many sections are well over half a century old and not robust enough to withstand the rigors of intermittent power. Be that as it may, as more turbines and solar panels come on line the grid will have to be upgraded appropriately.

At the North Central Correctional Facility in Gardner, Massachusetts, two brand new first quality Vestas 1.65 MW turbines remain offline because the antiquated local grid is unable to accommodate their intermittent power. More importantly, this venture has cost the taxpayers of the Commonwealth eleven million dollars. In a conversation with an engineer from the National Grid, I learned that they are planning to have these turbines on line sometime in 2013 after grid upgrades. At that time these turbines will have been idle and generating no return on investment for over two years. The fact that the project was initiated without a prior local grid analysis and upgrade is a conundrum.

ENVIRONMENTAL CONSIDERATIONS:

The carbon and thermal consequences of fossil fuel combustion are a continuing concern. And it is important to remember that obtaining deep or strip-mined coal, drilled petroleum, and fracked gas causes additional environmental problems.

Moreover, the decommissioning of a coal, oil, or gas power plant at the end of its service life is a formidable and extraordinarily expensive process. Often the ground beneath the plant is contaminated as well.

Decommissioning a nuclear power plant and storing its accumulated radioactive waste presents a constellation of difficulties. For example, at the dismantled Yankee nuclear plant in Rowe Massachusetts, the reactor's used fuel rods remain stored onsite in sixteen 110-ton concrete casks to this day. There is an ongoing cost of eight million dollars per year to keep this nuclear waste secure.

Proper long- term storage of spent fuel is an engineering problem that is yet to be resolved. As of this writing, construction of the underground federal storage facility for nuclear waste at Yucca Mountain remains suspended despite being 95% complete, as a result of a congressional mandate.

Conversely, at the end of a wind turbine's service life of about a quarter of a century, the entire modular structure can be disassembled, trucked from its site, and recycled or rebuilt. Disassembly can be completed in as little as two days. A new or remanufactured turbine assembly can then be erected in about a week. If the decision is made not to replace the turbine, all that remains is an inert fifteen-foot circular reinforced concrete platform just above grade that could be used as an *extraordinarily* sturdy base for a fire tower or simply as a support for two or three picnic tables.

However there are some environmental problems with wind energy. One of the greatest concerns is avian and bat fatalities.

A study in 2009 by B.K. Sovacool "Contextualizing avian mortality: A preliminary appraisal of bird and bat fatalities from wind, fossil-fuel and nuclear electricity" showed that the number of birds/bats killed by wind turbines is very low compared to the number of those that die as a result of certain other ways of generating electricity. According to Sovacool, fossil fuel kills around twenty times as many birds per unit of energy as wind farms.

Clearly a single study does not exonerate an entire industry. Of the eight turbine sites that I visited, I was able to interview four of their owners/managers about avian and bat deaths.

At Jiminy Peak in Hancock Massachusetts, the VP of Operations, Mr. James Van Dyke, told me that they have recovered only two small bird carcasses in two years of operation.

At the Williams Stone Company in East Otis Massachusetts, the company president, Ed Williams (now there's a star-crossed name) told me that in one full year of operation there had been no bird strikes until two weeks before our interview. During that time there was a week of unusually heavy fog and two small bird carcasses were found. Mr. Williams hypothesizes that the birds either blindly flew into the blades or simply the obscured structure itself. Interestingly, a family of ravens has been in residence at the quarry for generations and seems to have no problem with the turbine.

At Berkshire East, the general manager, Mr. Jon Schaefer, has observed no bird strikes in its first half year of operation.

However at the Mt. Wachusett Community College wind farm (two Vestas 1.65 MW turbines) an ongoing avian and bat study recorded five bat deaths in the month of July 2011 (bats migrate in the late summer/early fall). During the month of August I observed one pigeon carcass.

It is important to note that the current second generation slow turning (14 – 28 RPM) machines have blades that are easily visible (to birds) at design speeds. This was not true of the small high speed first generation 'California Machines' that were notorious for bird strikes.

However, the seeming inability of a bat's acoustic ranging system to detect and avoid even a slowly rotating turbine merits continued study and concern. It may be possible to design an electronic transmitter that would mimic the acoustic signature of an easily avoidable rock face.

Wind energy does have its engineering and environmental challenges, but with careful design and planning most and hopefully all can be remediated.

ECONOMICS OF WIND ENERGY:

From one perspective a wind turbine is an expensive piece of capital equipment. The aforementioned popular Vestas V82 typically has an installed cost of four million dollars per unit, not including the variable costs associated with access road construction or grid upgrades. Payback on the original investment can take between five and twelve years. Clearly this is a function of the local cost of electricity. For example, the College pays only about four cents per KW for its grid-sourced power not including the additional electricity produced by the power plant on the east side of campus. However the residents of Nantucket Island whose power is delivered via a twenty-one mile undersea cable pay over eighteen cents per KW. Clearly capital payback is directly linked to the cost of power from the local grid.

OUTLOOK FOR WIND ENERGY:

Is wind energy here to stay? It is.

Denmark is a shining example. The country is now producing over 20% of its power with wind energy, and more turbines are scheduled for installation both on land and at sea.

Will wind be the *sole* solution to the energy and environmental dilemmas facing our nation and the rest of the world? Not entirely. Here are some reasons why. The proven Vestas V82 mentioned throughout this outline "only" produces 1.65 MW yet the nearby and comparatively "small" Mt. Tom coal fired plant produces 142 MW. Thus 86 individual V82's would be required to equal the output of Mt Tom. In this part of the country, sighting 82 turbines at a single location is unrealistic. Nonetheless, every turbine that comes on line allows a carbon emitting plant to be "throttled back" and emit less pollution.

On an equally encouraging note, there are now wind farms, notably in the Midwest, with more than one hundred individual turbines. And offshore facilities hold great promise.

However there are many parts of this country where there is simply not enough space, enough wind, or too much local opposition to make the installation of turbines feasible. We will explore these and other topics in greater detail during the seminar.

SUMMARY:

We do not strip mine the wind. We do not extract it from deep, dark, dangerous shafts. We do not frack it. We do not drill for or transport it at demonstrated environmental peril. And we most assuredly don't burn it.

The wind is free … it is clean … it is inexhaustible. There is indeed hope for the future of this wonderful resource.

In a well-crafted line from a melancholy tune a half century ago, Donovan sang "Ah … but I may as well try and catch the wind." His pessimism was misdirected; for if we but trim the sails, we can indeed catch the wind.

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The instructor for this seminar has visited eight turbine sites and one utility scale solar facility in the Commonwealth and Vermont. He has met with some of their owners and managers, and interviewed a representative from the National Grid and the Massachusetts Department of Energy. He has also climbed the interior service tower to the nacelle of the Berkshire East turbine under the guidance of its general manager.

Much of this document has been reviewed by Professor James Manwell of the Wind Energy Department at the University of Massachusetts; however the opinions herein are the author's.

For the past six years "Captain Henry" has been teaching "Celestial Navigation" and "An Introduction to the Principles, Practices, and Procedures of Turbine Flight" during the Amherst College Interterms.


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